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PSITTACINE GROWTH: MEASUREMENT OF DAILY WEIGHT ON A PSITTACINE NURSERY

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Thesis submitted to the Faculdade de Medicina Veterinária in partial fulfillment of the requirements for the degree of Master in Veterinary Medicine at Universidade Lusófona de Humanidades e Tecnologias.

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Experience (...) was merely the name men gave to their mistakes.

Oscar Wilde

in The Picture of Dorian Gray

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Ao Loro Parque, por aceitar o meu estágio curricular e permitir cumprir um sonho quase tão antigo como a minha existência.

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ABSTRACT

Measuring newborns weight gain per day can be a useful tool to determine if these baby chicks are growing as expected for a healthy bird. Although its importance is acknowledged, current information on what is the expected weight gain/day of a newborn psittacine is limited. The general goal of the present thesis is to determine the standard value of weight gain/day in selected species of psittacines. This study aimed to provide charts and tables and supply a reliable framework for those interested in pediatric psittacine health. All data was obtained in Loro Parque from chicks incubator-born or nest-born from January 2011 to December 2011. For the descriptive analysis SPSS/PASW 20 IBM was used. Disease was taken into account, so animals were stratified into healthy and sick groups. Weight mean in grams by day and respective upper and lower confidence interval (CI) were found. A CI of 95% was applied. All growth curves were obtained with these data. When N<3 (N being the number of psittacines of one species) both upper and lower CI withdraw from the media line, decreasing the confidence of the results. When 3<N<8 an increased confidence of the results was observed. When N>8 both upper and lower CI stood close to the media line, increasing the confidence of the results. These results are in conformity with what was expected. Curves from the following species reached this study's purpose, being representative of their growth: *Ara glaucogularis*, *Aratinga solstitialis*, *Cacatua galerita*, *Poicephalus robustus*, *Psittacus erithacus*, *Pyrrhura perlata* and *Trichoglossus haematodus*. This is the first study on weight gain/day for these species. With this study it was possible to elaborate and provide tables with the expected weight/day of a healthy psittacine chick from hatching until fledging.

Keywords: Psittacine, growth, weight, chick, nursery.

ABSTRACT

Die Messung der täglichen Gewichtszunahme von Neugeborenen kann ein nützliches Werkzeug sein, um zu entscheiden, ob das Wachstum dieser Babys dem eines gesunden Vogels entspricht. Obwohl die Wichtigkeit dieser Messungen anerkannt ist, ist die aktuelle Information über das zu erwartende Gewicht pro Tag eines neugeborenen Papageienvogels beschränkt. Das allgemeine Ziel der vorliegenden Arbeit ist es, einen Standartwert für die Gewichtszunahme/Tag bei ausgewählten Papageienarten festzulegen. Der Zweck dieser Studie ist es, denen am Pädiatriebereich von Papageienvögeln Interessierten, Diagramme und Tabellen, sowie einen zuverlässigen Arbeitsrahmen zur Verfügung zu stellen. Alle Daten wurden von Januar bis Dezember 2011 im Loro Parque von Brutkasten- sowie Nestküken gesammelt. Für die beschreibende Analyse wurde SPSS/PASW 20 IBM verwendet. Krankeiten wurden berücksichtigt, und deshalb die Tiere in gesunde und kranke Gruppen statifiziert. Der Gewichtsmittelwert in Gramm pro Tag und die respektiven oberen und unteren Konfidenzintervalle (CI) wurden ermittelt. Ein CI von 95% wurde angewandt. Alle Wachstumskurven wurden mithilfe dieser Daten ermittelt. Für $N<3$ (N ist die Anzahl der Papageienvögel einer Gattung) gehen der untere und obere CI bezüglich des Mittelwerts auseinander, was die Konfidenz der Ergebnisse erhöht. Für $3<N<8$ wurde eine erhöhte Konfidenz der Ergenisse beobachtet. Für $N>8$ befanden sich sowohl der obere wie untere CI in der Nähe des Mittelwertes. Diese Ergebnisse stehen in Überstimmung mit den erwarteten Werten. Kurven für die folgenden Gattungen erzielten den Zweck dieser Studie, da sie repräsentativ für ihre Gattung sind: *Ara glaucogularis*, *Aratinga solstitialis*, *Cacatua galerita*, *Poicephalus robustus*, *Psittacus erithacus*, *Pyrrhura perlata* und *Trichoglossus haematodus*. Das ist die erste Studie zur Gewichtszunahme/Tag für diese Gattungen. Mit dieser Studie war es möglich, Tabellen mit dem erwartetem Gewicht/Tag eines gesunden Papageienkükens, vom Schlüpfen zum ersten Flug, zu erstellen und anzubieten.

Schlüsselwörter: Papageienvögel, Wachstum, Gewicht, Küken, Vogel-Kinderstube

RESUMO

Os psitacídeos são Aves que habitam zonas tropicais e subtropicais como a Australásia, Oceânia, América do Sul e África. Existem perto de 400 espécies divididas em 85 géneros diferentes, todos eles incluídos na ordem dos Psittaciformes. A ordem dos Psittaciformes encontra-se dividida em três superfamílias: Psittacoidea, Cacatuoidea e Strigopoidea sendo feita, desta forma, uma divisão entre os "verdadeiros papagaios", cacatuas e os papagaios Neozelandeses, respectivamente.

Actualmente, os psitacídeos encontram-me espalhados por todo o mundo. Podemos atribuir este fenómeno ao crescente comércio destas espécies, mas é também a sua capacidade de adaptação que os torna aptos a viver em ambientes onde, em princípio, não estariam reunidas as condições ambientais propícias ao seu desenvolvimento. Estas populações ferais provaram ser bastante resilientes e hábeis a adaptarem-se a condições como as encontradas na Europa e América do Norte.

À medida que foram ganhando popularidade mundial, o seu estatuto de sobrevivência foi sendo ameaçado pelo comércio ilegal e perda do habitat natural. Por esse motivo, hoje em dia, o comércio destas aves é rigorosamente controlado pelo CITES (em tradução livre Convenção para o Comercio Internacional de Fauna e Flora Silvestre) e, a maioria das espécies hoje disponíveis, são oriundas de criadores particulares e parques zoológicos. Apesar da maioria dos psitacídeos actualmente comercializados serem provenientes de cativeiro, é importante ser feita uma distinção entre animais de estimação, animais de exibição (como aqueles presentes em parques zoológicos) e animais de projectos de conservação. Para todos eles, o CITES tem clausulas especificas em relação à sua deslocação pelo mundo.

O presente trabalho foi realizado no Loro Parque, instituição que tem a maior colecção de psitacídeos do mundo, com perto de 4.000 indivíduos divididos por cerca de 350 espécies e subespécies. É, por isso, utilizado como ponto de referência em inúmeros estudos com psitacídeos. Associada ao LP está a Loro Parque Fundación (LPF), uma associação internacional não lucrativa dedicada à necessidade emergente de conservação destes animais e dos seus habitats. Envolvida em centenas de projectos desde 1994, destacam-se os dois programas de reprodução e conservação de *Cyanopsitta spixii* e *Hapalopsittaca fuertesi*. A LPF está, por isso, na Lista de Doadores Aprovados (tradução livre) da CITES, comerciando inúmeras espécies autorizadas e utilizando os lucros obtidos nos seus projectos de conservação.

Para além do centro de exposições, o LP tem, ainda, uma clínica veterinária, um laboratório interno e um viveiro denominado de Baby Station (BS). É na BS que as crias são criadas à mão até estarem aptas a comer e beber por si (*fledgling*). A partir do momento em que nasce, cada cria é pesada e examinada por um operador treinado. O peso é registado juntamente com alterações físicas como a coloração das mucosas, distensão abdominal, alterações músculo-esqueléticas, impactação do papo, entre outras. Não sendo registadas alterações, cada animal é alimentado com o auxílio de uma cânula, uma papa específica para a idade e espécie. A cria é, então, limpa, o umbigo desinfectado com uma solução de clorhexidina a 0,5% e colocada numa incubadora a temperatura óptima para a idade e espécie. O processo de alimentação é repetido tantas vezes quanto as necessárias para a espécie em questão. O tempo compreendido entre alimentações pode alterar consoante diversos factores: neonatos, espécies pequenas e baixa condição corporal são exemplos para que o tempo entre alimentações diminuía, crias com mais de quatro dias, espécies maiores e aumento da condição corporal são exemplos para que o tempo entre alimentações aumente. A quantidade de alimento depende, também, de alguns factores. Entre o primeiro e o quarto dia são administradas doses de 0,1 mililitros de alimento, depois desse dia a quantidade de alimento passa a ser determinada pela condição corporal. Regra geral, as crias são alimentadas com quantidades equivalentes a 10% do seu peso corporal. A transição entre papa e alimento sólido depende de animal para animal. Quando uma cria passa a ser alimentada apenas duas vezes por dia, são introduzidas frutas, legumes, pequenos frutos secos e alimento granulado. A água é introduzida quando a alimentação assistida é reduzida a uma única toma.

Todos os viveiros de psitacídeos se deparam com factores de risco que comprometem o crescimento. É importante referir que a perda de peso é, muitas vezes, o primeiro sinal de doença em neonatos e jovens crias. Os factores de risco mais frequentes são o maneiro dietético, variações de temperatura, erro humano e problemas de desenvolvimento/congénitos.

O inadequado maneio dietético é responsável pela maioria dos problemas observados em psitacídeos adultos e a razão pela qual muitas crias não sobrevivem em cativeiro. Uma vez que existem espécies tão distintas é de esperar que os requisitos nutricionais sejam, também eles, distintos. Uma dieta inadequada é, não só responsável por condições corporais aberrantes mas, também, por hipovitaminose A, doenças metabólicas, deficiência de iodo, obesidade e doenças associadas à lipidose hepática. Não é só a constituição do alimento que desempenha um papel importante no maneio dietético, a sua preparação tem, também, de cumprir requisitos de temperatura e de formulação, sendo necessário utilizar água própria para consumo humano.

A temperatura tem um papel primordial, pois os neonatos são incapazes de regular a sua temperatura corporal. Dependem, por isso, da temperatura seleccionada na incubadora, pelo que temperaturas demasiado baixas ou demasiado altas predispõem a cria a doenças e comprometem o aumento do peso.

O erro humano é directamente dependente do treino e experiencia do operador. Este, é o responsável por garantir que a temperatura é a ideal para a cria, que o substrato utilizado é inócuo, que a papa é preparada seguindo todos os critérios de segurança e higiene e que são utilizados métodos e produtos de desinfecção e limpeza eficazes e seguros para as jovens crias. Para além disso, a avaliação diária e o horário de alimentações devem ser sistemáticos de forma a diminuir as hipóteses de erro.

Os problemas congénitos não são previsíveis e não têm, geralmente, cura. Os problemas de desenvolvimento, por sua vez, podem surgir como consequência de mau maneio, deficiências nutricionais ou problemas na incubação. Os sinais de doença que se seguem são aqueles que, regra geral, têm um maior impacto no crescimento das crias: malformações congénitas, malformações do bico, regurgitação, esofagite, faringite, perfuração de esófago ou faringe, estáse do papo, queimaduras de papo, ingestão de corpo estranho e impactação.

Apesar de este estudo ter sido feito utilizando dados obtidos em cativeiro, outros estudos semelhantes foram feitos em espécies de psitacídeos no seu habitat natural. Estes estudos mostram como o controlo de variáveis é importante e como estas têm um impacto substancial no aumento de peso das crias. As curvas obtidas nestes estudos mostraram, ainda, que os padrões obtidos seguiam padrões de crescimento semelhantes.

O objectivo do presente estudo é, através da medição diária do peso, determinar o valor padrão de crescimento de espécies seleccionadas de psitacídeos.

Os dados obtidos no presente estudo foram recolhidos durante um ano (Janeiro de 2011 a Dezembro de 2011), a partir de crias de psitacídeos nascidas no Loro Parque. A escolha do peso como padrão biométrico foi feita por esta ser uma medida objectiva e de fácil obtenção, requerendo, apenas, uma balança e mínima manipulação dos animais. Apesar da ovo postura ser feita no ninho, os ovos foram recolhidos e incubados artificialmente. No caso dos ovos que eclodiram no ninho, as crias foram recolhidas e criadas nas mesmas condições daquelas nascidas directamente na incubadora. Nenhum dos animais do estudo foi criado pelos progenitores. No total foram pesados 527 indivíduos separados em 115 espécies e 37 subespécies, num total de 16.996 pesagens.

Foram obtidos dois registos diferentes, um de animais que nasceram na incubadora e outro dos animais nascidos no ninho. Ambos os registos começavam no primeiro dia de pesagem e terminavam aquando da saída das crias da BS. As crias vindas do ninho não eram pesadas logo no primeiro dia após o nascimento, sendo feito, primeiro, um cálculo estimativo da sua idade em dias. A primeira pesagem começava, então, no dia calculado e não no dia 1.

A analise estatística foi feita utilizando o SPS/PASW 20 IBM e aplicada a 296 animais num total de 15 espécies e 10.884 registos. Após determinado o desvio padrão, o intervalo de confiança (CI) e o peso médio em gramas, foi utilizado o Microsoft Excel 2010 para obtenção das curvas de crescimento.

Este não é um estudo comparativo mas sim um censos da população total. Assim sendo, quanto maior o numero de indivíduos (N) estipulado, menor a variabilidade dos resultados. Por esse motivo, determinou-se que N=8 seria o número mínimo de indivíduos necessário para reduzir a variabilidade entre as pesagens.

Foram estabelecidos os seguintes critérios de inclusão: indivíduos nascidos no LP entre Janeiro de 2011 e Dezembro de 2011, que permaneceram saudáveis durante todo o estudo. Os critérios de exclusão foram: indivíduos que adoeceram durante o período de pesagem e espécies com menos de 8 indivíduos durante o período de pesagem. O critério que determinou o fim da pesagem foi o momento da saída da BS. Esse momento corresponderia, no seu habitat natural, à saído do ninho (*fledgling*). O momento para a saída do ninho varia significativamente entre espécies, subespécies e, até, entre indivíduos da mesma espécie. Geralmente, as aves maiores levam mais tempo do que as aves mais pequenas a atingir o *fledgling*.

Apesar de haver uma divisão entre registos do ninho e da incubadora, como a maioria dos indivíduos da mesma espécie não perfaziam o critério de inclusão, os pesos foram analisados num todo, independentemente da sua origem. Um total de 231 crias foram excluídas do estudo.

Após a análise estatística foram obtidos 15 gráficos diferentes, correspondendo cada um a uma espécie distinta. Os gráficos representam os intervalos de confiança superior, inferior e a média do crescimento em peso/dia dos indivíduos saudáveis daquela espécie.

Após a obtenção das curvas de crescimento, verificou-se que dois dos gráficos se desviavam do padrão obtido nos restantes gráficos. Foi feita uma nova leitura dos dados e verificou-se que, apesar de, no inicio do estudo, as espécies consideradas terem um N ≥ 8, após os critérios de exclusão serem aplicados esse numero diminuiu. Apesar de apenas esses dois gráficos se apresentarem aberrantes, outras espécies apresentavam um N < 8.

Foram obtidos 15gráficos de crescimento para as seguintes espécies: *Amazona vinacea*, *Ara glaucogularis*, *Aratinga solstitialis*, *Cacatua ducorpsii*, *Charmosyna papou*, *Eclectus roratus*, *Cacatua galerita*, *Eolophus roseicapilla*, *Nestor notabilis*, *Pionites leucogaster*, *Poicephalus robustus*, *Primolius couloni*, *Psittacus erithacus*, *Pyrrhura perlata* e *Trichoglossus haematodos*. Foram, também, obtidos dois gráficos relativos à prevalência de doença. O primeiro mostra a prevalência dos sinais de doença observados no total e, o ultimo, a sua prevalência por espécie.

Quando N<3 os CI's superior e inferior afastam-se da linha da média, diminuindo a confiança dos resultados. Quando 3<N<8 observou-se um aumento da confiança dos resultados. Quando N>8 os CI's superior e inferior mantiveram-se perto da linha da média, aumentando a confiança dos resultados. Com excepção de dois gráficos, os padrões de crescimento obtidos estão em conformidade com a literatura.

No caso de todas as crias terem a sua origem no ninho, o CI afasta-se, inicialmente, da linha da média, convergindo ao longo do tempo. Uma vez que, no ninho, não é feito o controlo de variáveis, crias com a mesma idade podem apresentar pesos diferentes, que vão convergindo quando passam a ser criadas nas condições controladas da incubadora.

Os picos de crescimento transitórios observados em alguns gráficos foram associados a erros de registo. Os picos de crescimento que tendem a convergir com a linha da média, estão associados á entrada de indivíduos provenientes do ninho. Nos casos em que várias subespécies foram agrupadas numa só espécie, é esperado um desvio na amplitude do CI. O mesmo fenómeno é esperado em espécies com demarcado dimorfismo sexual. A diminuição de peso, observada no fim de algumas das curvas de crescimento, é associada ao período de saída do ninho.

Os objectivos do presente trabalho foram conseguidos para as espécies: *Ara glaucogularis*, *Aratinga solstitialis*, *Cacatua galerita*, *Poicephalus robustus*, *Psittacus erithacus*, *Pyrrhura perlata* e *Trichoglossus haematodus*. É possível comparar os valores obtidos com a literatura existente no caso de *Psittacus erithacus* e *Cacatua galerita*, por já existirem dados para estas duas espécies. Para as restantes espécies a comparação terá de ser feita por extrapolação e baseada em padrões de crescimento obtidos para outras espécies, quer em cativeiro quer em estado silvático.

Apesar de não ser parte do objectivo deste estudo, foi feita uma avaliação da variável doença. A identificação dos sinais de doença em psitacídeos pode ser um desafio, pois as directivas existentes não são completamente objectivas, o que dificulta o processamento dos dados. Dada a sua subjectividade, muitas aves classificadas como saudáveis morreram durante o período de pesagem e tiveram de ser classificadas como doentes. A maioria dos sinais de doença encontravam-se associadas a problemas de maneio, pelo que o controlo desta variável se deverá traduzir numa maior taxa de sucesso dos viveiros.

Com este estudo foi possível elaborar e obter tabelas com aquele que será o peso/diário esperado para uma cria saudável de psitacídeos, desde a nascença nasce até à altura em que sai do ninho.

Este é o primeiro estudo do género para uma variedade de espécies e pode, ainda, ser extrapolado para espécies aparentadas. Este é, por isso, um estudo importante para criadores, biólogos, médicos veterinários, centros de recria e todos os interessados no crescimento de psitacídeos.

SYMBOLS AND ABBREVIATIONS

BS - Baby Station

BW - Body Weight

CI - Confidence Interval

CITES - Convention on International Trade in Endangered Species of Wild Fauna and Flora

F - Fahrenheit

Gr - Gram

i.e. - in example

Kg - Kilogram

LBC - Low Body Condition

LP - Loro Parque

LPF - Loro Parque Fundación

SOD - Sign of Disease

USA - United States of America

YSR - Yolk Sac Retention

ºC - Celsius

ẋ - Mean

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INTRODUCTION

Psittacines are birds and, as all birds, they descend from dinosaurs (Macwhirter, 2009b). It is unknown when the first bird existed, since it is relatively difficult to follow a fossil record (avian bones are fragile and not easily preserved) (Macwhirter, 2009b). The first known fossil of a bird is the *Archaeopteryx lithographica* with one hundred and forty million years of age. Modern birds have only few million years of age and the older psittacine known is from the Eocene-Oligocene of Europe and North America (Collar, 1997).

Found in tropical and subtropical regions (Joseph *et al.*, 2012) like Australasia, Oceania, South America and Africa (Steadman, 2006; Wright *et al*., 2008) and with almost four hundred species divided by eighty five genera, psittacines form the Psittaciformes order (Peterson, 2013). According to Joseph *et al.* (2012) there are three superfamilies dividing the Psittaciformes order: Psittacoidea (the true parrots), Cacatuoidea (known as cockatoos) and Strigopoidea (the New Zealand parrots).

Nowadays psittacines are found all over the world, not only because of the pet trade but also due to some species ability to become established outside their natural ranges (Sol *et al*., 1997; Butler, 2005). These feral populations have proved surprisingly hardy in adapting to conditions such as Europe and North America (Butler, 2005). While gaining worldwide popularity, some species became increasingly endangered (Food and Agriculture Organization [FAO], 2011). Nowadays pet bird trade is strictly controlled (Convention on International Trade in Endangered Species of Wild Fauna and Flora [CITES], 2010; Fish and Wildlife Service [FWS], 2012) and most species now available are bred in captivity by private breeders and zoological parks (CITES, 2010). When talking about captive-bred psittacines, it is important to distinguish between pet birds, exhibition birds and avian conservation projects (CITES, 2010).

PSITTACINE BREADING ROUTINES AT LORO PARQUE

The Loro Parque (LP) owes the biggest collection of Psittacines in the world, with almost 4.000 individuals divided by about 350 species and subspecies (www.loroparque.com). With such numbers it is not unexpected that the park is used as main reference in many studies. In 1994 LP founded the Loro Parque Fundación (LPF), an international non-profit organization dedicated to the emergent need for conservation of animals and their habitat in nature. The foundation has been, since then, active in almost one hundred conservation projects in many different countries. LPF is particularly active in the conservation and breeding program of endangered psittacines, like *Cyanopsitta spixii* and *Hapalopsittaca fuertesi* (Loro Parque S.A., 2011).

By the end of 2011, the LPF had bred and leg-ringed 1.350 parrot chicks of 180 species and subspecies. Many of these were exchanged within official cooperative breeding programs for threatened species (Loro Parque S.A., 2011). The LPF is on the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) List of Approved Donors and the total sales in 2011 of surplus parrots of certain species reached 270.873€ all the income derived from these sales was directed to the conservation projects of the LPF (Loro Parque S.A., 2011).

The following description is based on observations made by the author in Loro Parque.

Apart from the exhibition itself, there is a veterinary clinic (Figures 1 and 2) that assists the park and the foundation, an in-house laboratory and a nursery named "Baby Station" (BS) where the young chicks are hand-raised until they are able to eat and drink by themselves (Figures 3 to 6).

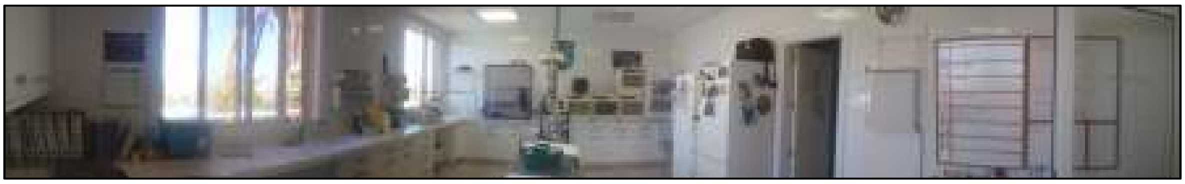

Figure 1. Loro Parque's examination room (original from the author).

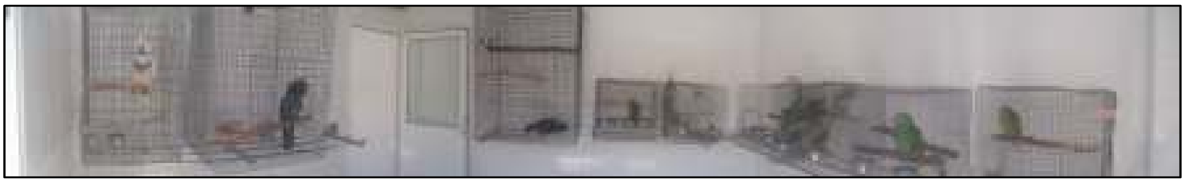

Figure 2. Loro Parque's treatment room (original from the author).

Figure 3. Baby Station - Incubators (original from the author).

Figure 4. Baby Station - Incubator showing a chick of *Cacatua moluccensis* (original from the author).

Figure 5. Baby Station - Chicks on weaning process (original from the author).

Figure 6. Baby Station – Three days old chicks in incubator (original from the author).

Once the chick is hatched, a daily routine is fulfilled: because weight loss is one of the first signs of disease (Romagnano, 2012) each bird is weighted and examined by a trained technician. Its weight gain (or loss) is registered as well as any abnormal signs such as mucosa discoloration, abdominal distension, musculoskeletal changes, and crop impactation, among others. If no abnormal signs are noticed, each animal is fed a baby formula with the help of an esophageal cannula. Formula and method of feeding is adapted to the species and its life stage. The young chick is then cleaned and its umbilicus swabbed with chlorhexidine solution at 0,5% and placed in its own incubator at an optimal temperature (temperature is adjusted according to the species). Feeding process is repeated as many times as necessary for each species. Time between feedings can decrease (i.e. neonates, small species, low body score, signs of wasting syndrome, crops stasis, etc.) or increase (above 4 day old chick, bigger species, high body score, weaning, etc.). At day one about 0,1ml of formula is given. From day four forward, body weight (BW) is used to determinate the amount of formula given. At this stage, most species are fed 10% of their BW. Weaning is done in the BS. Transition time depends on each species. When the chick is at two feedings a day, pellets, fruit, vegetables and small nuts are introduced. Water bowls are provided when the chick is at one feeding a day.

Every psittacine nursery has to deal with the following risk factors that can interfere with the weight gain: dietary management, temperature variations, human error and congenital/development problems.

Figure 7. Example of feeding process (original from the author).

Diet is the reason why most adult parrots present health issues and why some chicks do not survive in captivity (Romagnano, 2012). Since there are such a large number of species, there are different types of dietary requirements (Macwhirter, 2009a). Generally, the basic diet in the wild is seeds, fruits, nectar, pollen and buds (Collar, 1997). Some particular species can also eat arthropods and other small prey (Collar, 1997). Incorrect diets are responsible for abnormal body scores, hypovitaminosis A, calcium-phosphorus metabolic diseases (such as metabolic bone disease and choanal atresia), iodine deficiency, obesity and related disorders such as hepatic lipidosis (Bauck, 1995; Birdlife International, 2011). With formulated diets it is easier to calculate protein, fat, vitamins and mineral intake. Moreover, birds are completely dependent on the amount of formula given by the breeder (Bauck, 1995) (Figure 7). The commercial formula used also intends to mimic the feeding consistency of their natural food, being carefully adapted to the young chick age (www.loroparque.com; www.versele-laga.com). Psittacine chicks do best on higher-fat diets, unless they are prone to obesity and hepatic lipidosis, like *Cacatua alba* and *Cacatua moluccensis* (Romagnano, 2012). According to Romagnano (2012) the percentage of solids from the powdered formula mixed should be 27%. For birds of conure size and up, Romagnano (2012) proposes a gradual decreased frequency of formula feeding after day three (after hatching), from five times a day to one feeding a day. Chicks are gradually moved down depending on theirs species and individual size. Water bowls should be introduced when the birds are at one feeding a day. Once birds are drinking and eating on their own, they can be moved into larger cages (Romagnano, 2012).

Handfeeding formula should be mixed with clean, mineral hot water. The temperature of the final formula mix should be between 40 Celsius (ºC) (105 Fahrenheit (F)) and 42ºC (108 F). Temperatures lower than 40ºC may result in crop stasis and formula aspiration as chicks will not pump if the formula is not warm enough. Temperatures of 42.5ºC (109 F) or higher or microwave reheating will result in crop burns (Romagnano, 2012)

Because neonates are unable to thermoregulate, temperature is determined by its species and set in the incubator. The only variations occurred when the bird was being manipulated during the daily routine at room temperature controlled by air conditioner. Since neonates cannot thermoregulate, excessive or lower temperatures can make the animal prone to diseases and compromise the weight gain (Romagnano, 2012).

Figure 8. Example of substrate (original from the author).

Human error can be the most important risk factor in a nursery if staff is not properly trained. It is important to know if the neonate is being kept at the correct temperature for its age and size. Both container and substrate are important, as they may contribute to management-related diseases. Good substrate should not be slippery as it may cause splayed legs; and should be harmless if swallowed in order to prevent crop impactation, suffocation, aspiration and death. Paper towels are an example of proper substrate. The type of substrate can change according to the chicks age (Figure 8). Also the hand-feeding formula utensils, their handling and storage need to be evaluated as improper cleaning or incorrect formula blend can cause problems such as bacterial or fungal infections and insufficient energy intake (Schulte & Rupley, 2004; Wissman, 2006). Hot soapy water wash, followed by soaking in diluted Pfizer's Roccal-D® (didecyl dimethyl ammonium chloride and alkyl dimethyl benzyl ammonium chloride) and rinsing with a very diluted chlorhexidine mixture, is a safe option (Romagnano, 2012). Daily chick examination must be systematic so chance of error is minimized (Schulte & Rupley, 2004; Wissman, 2006). Every chick should be fed on schedule. Unless the bird is sick or a hard keeper (poor doer) it is not necessary to feed chicks after midnight and before sunrise as they need to rest and empty the crop (Romagnano, 2012).

Congenital deficiencies are not predictable and usually are not treatable (Flammer & Clubb, 1997). According to Wissman (2006) congenital problems are not very common, being the most frequent congenital heart disease (ventricular septal defect) and *Psittacus erithacus*' choanal atresia. Other reported congenital defects are familiar cataracts, hydrocephalus and uni or bilateral anophtalmia (Wissman, 1995).

Development problems may occur as a result of injury, poor husbandry practices, malnutrition or from problems during incubation, as earlier described (Wissman, 1995).

Infectious problems can occur from viruses, bacteria, fungi, protozoa or parasites (Wissman, 1995). The most common virus in nurseries is Polyomavirus with a very high mortality rate, followed by the Bornavirus responsible for the Proventricular Dilatation Disease (PDD) and the Circovirus of Psittacine Beak and Feather Disease (PBFD). As for bacterial infections, *E. coli*, *Klebsiella* spp., and *Enterobacter* spp. are only relevant if there are any clinical signs. Presence of *Pseudomonas* spp. and *Salmonella* spp. should always be considered pathogenic. *Candida* spp. is the fungi with higher prevalence. *Chlamydophilia* is also one of the most common infectious diseases in nurseries (Wissman, 1995; Romagnano, 2012).

Common pediatric problems/diseases affecting weight gain include: congenital malformations, beak malformations, regurgitation, esophagitis, pharyngitis, esophageal or pharyngeal punctures, crop stasis, crop burns, foreign body ingestion and impactation (Clubb, 1997; Flammer & Clubb, 1997).

DESCRIPTION OF THE SPECIES INCLUDED IN THIS STUDY

The following descriptions aim to enlighten the reader about the fifteen psittacine species that were studied in the present work.

AMAZONA VINACEA

Amazon vinacea, also known as Vinaceous Amazon, is a midsized stocky parrot (about 30cm and 370gr), with short slightly rounded tail and broad rounded wings (Figures 9 and 10). It displays no sexual dimorphism and juveniles have usually dimmer colors than adults. This bird is arboreal and lives in pairs or in small flocks. sexual dimorphism and juveniles often lack features of adults, being difficult to identify. It is mostly arboreal but does some ground feeding. *A. vinacea* can be found in southeastern Brazil, from southern Bahia to western Espírito Santo, south to northeastern Argentina, in Misiones and possibly northeastern Corrientes and southeastern Paraguay (Figure 11). It is in CITES list of critically endangered species (Forshaw, 2010).

Figure 9. *A. vinacea*'s chick (by Karen McGovern).

Figure 10. *A. vinacea*'s adult (by Luiz Claudio Marigo).

Figure 11. *A. vinacea*'s distribution in the world (http://www.oiseaux.net).

Ara glaucogularis

Ara glaucogularis, also known as Blue-throated Macaw, is a large parrot (about 85cm and 750gr), with massive bill and long, strongly graduated tail (Figures 12 and 13). There is no sexual dimorphism and juveniles resemble adults. This bird is arboreal but will go to the ground to collect palm nuts. Lives in pairs or small groups. *A. glaucogularis* can be found in east to upper Rio Mamoré in Llamos Mojos and in El Beni in Central Bolivia (Figure 14). It is in CITES list of critically endangered species (Forshaw, 2010).

Figure 12. *A. glaucogularis'* chick (by Brent Barret).

Figure 13. *A. glaucogularis’* adult (by Luiz Claudio Marigo).

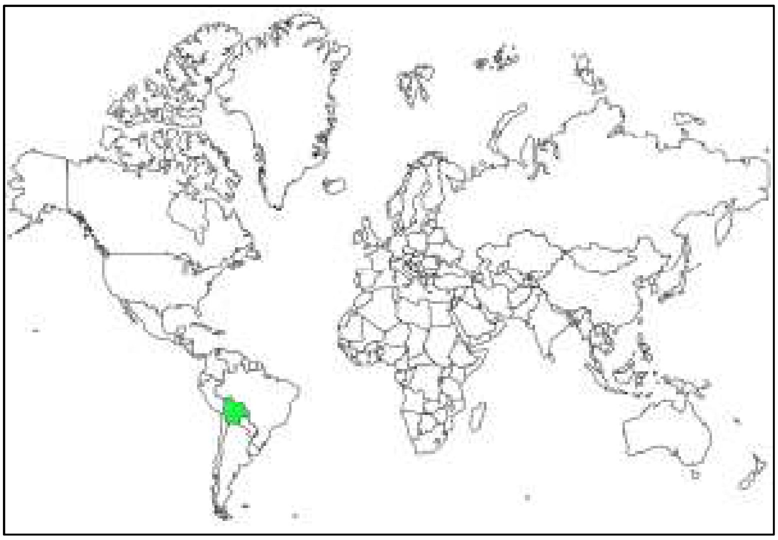

Figure 14. *A. glaucogularis’* distribution in the world (http://www.oiseaux.net).

ARATINGA SOLSTITIALIS

Aratinga solstitialis, also known as Sun Conure, is a midsized parrot (about 30cm and 120gr), with long, graduated tail (Figures 15 and 16). Displays no sexual dimorphism and juveniles often lack features of adults, being difficult to identify. This bird is arboreal but does some ground feeding. Lives in pairs or in large flocks. *A. solstitialis* can be found in northeastern Brazil, Guyana and possibly northwestern and southern Suriname and extreme southeastern Venezuela (Figure 17). It is in CITES list of vulnerable species (Forshaw, 2010).

Figure 15. *A. solstitialis*' chicks (by Gail J. Worth).

Figure 16. *A. solstitialis*' adult (by Graeme Knox).

Figure 17. *A. solstitialis*' distribution in the world (http://www.oiseaux.net).

CACATUA DUCORPSII

Cacatua ducorpsii, also known as Ducorp's Corella, is a midsized white cockatoo (about 31cm between 290gr and 415gr), with short recumbent crest, white and short bill and prominent bare eye-ring. It is the only all-white cockatoo (Figures 18 and 19). Displays no sexual dimorphism and juveniles resemble adults. This bird is mostly arboreal and lives in pairs or in small flocks. *C. ducorpsii* can be found in Bougainville and Buka Islands, easternmost Papua New Guinea, and Solomon Islands to Malaita, but apparently absent from San Cristobal group (Figure 20). It is in CITES list of vulnerable species (Forshaw, 2010).

Figure 18. *C. ducorpsii'*s chick (by Gail J. Worth).

Figure 19. *C. ducorpsii*'s chick (by Steve Milpacher).

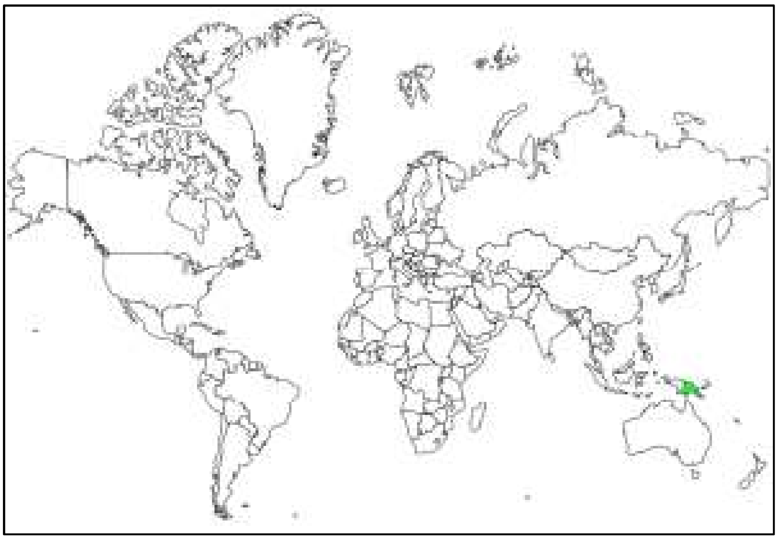

Figure 20. *C. ducorpsii's* distribution in the world (http://www.oiseaux.net).

CACATUA GALERITA

Cacatua galerita, also known as Sulphur-crested Cockatoo, is a large sized cockatoo (about 50cm 900gr), with forward-curving crest and black bill (Figures 21 and 22). Displays no sexual dimorphism and juveniles resemble adults. This bird is mostly arboreal in the north but ground feeds in the south. Lives in large flock in the south and in pairs or small flocks in the north. *C. galerita* can be found in northern and eastern Australia, New Guinea and western Papuan and Aran Islands, Indonesia. Introduced in southwestern Australia, New Zealand, Palau Islands in Micronesia, Kai Islands and some islands of East Moluccas, Indonesia and Taiwan (Figure 23). There are five poorly differentiated subspecies: *C. galerita galerita*; *C. galerita queenslandica*; *C. galerita fitzroyi*; *C. galerita triton*; *C. galerita eleonora*. It is in CITES list of vulnerable species (Forshaw, 2010).

Figure 21. *C. galerita*'s chick (by Gail J. Worth).

Figure 22. *C. galerita*'s adult (by Cheryl Moore).

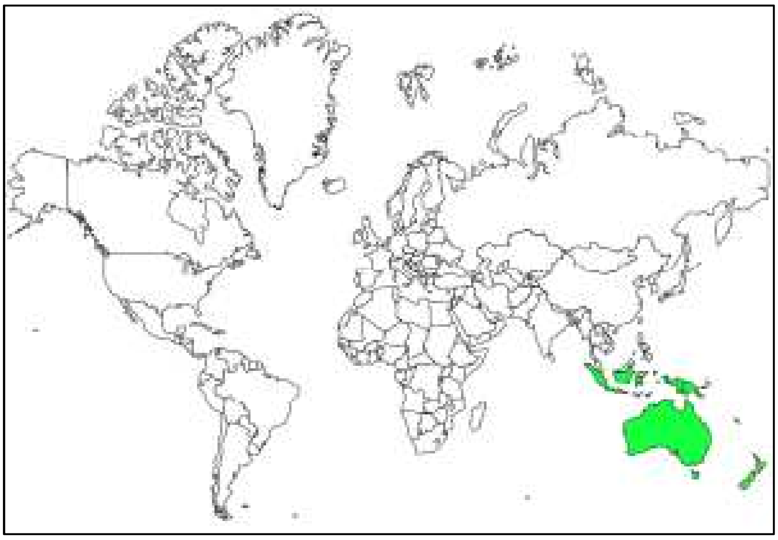

Figure 23. *C. galerita*'s distribution in the world (http://www.oiseaux.net).

CHARMOSYNA PAPOU

Charmosyna papou, also known as Papuan Lorikeet, is the largest red and green *Charmosyna* lorikeet (about 25cm and 100gr) with slender, sharply graduated tail and finely-pointed, compressed red bill (Figures 24 and 25). Displays sexual dimorphism and juveniles usually resemble female adults. This bird is mostly arboreal feeding on nectar, pollen, fruits and occasionally insects. They live in small groups. *C. papou* can be found in the mountains of mainland New Guinea (Figure 26). There are three well marked subspecies and one poorly differentiated subspecies: *C. papou papou*; *C. papou stellae*; *C. papou goliathina*; *C. papou wahnesi*. It is in CITES list of vulnerable species (Forshaw, 2010).

Figure 24. *C. papou*'s chick (by Tim Chong).

Figure 25. *C. papou*'s adult (by Ron Hoff).

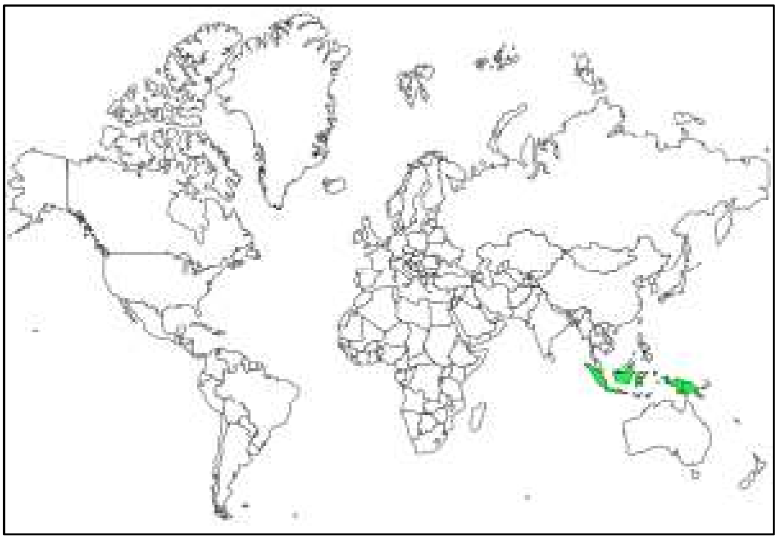

Figure 26. *C. papou*'s distribution in the world (http://www.oiseaux.net).

ECLECTUS RORATUS

Eclectus roratus, also known as Eclectus Parrot, is a large stocky parrot (about 35cm and 500gr), with short square-like tail (Figures 27 and 28). Displays a very distinctive sexual dimorphism with males being green and females red. Juveniles resemble adults**.** This bird is mostly arboreal. Lives alone, in pairs or small groups. *E. roratus* can be found in Moluccas and lesser Sunda Islands, Indonesia, east through New Guinea to Solomon Islands and Palau Archipelago, Micronesia (Figure 29). There are nine subspecies divided in three different groups according to female color: *E. roratus roratus* and *E. roratus wosmaeri* have a dim purple mantle; *E. roratus cornelia* and *E. roratus riedeli* are entirely red; *E. roratus polychlorus*, *E. roratus biaki*, *E. roratus aruensis*, *E. roratus macgillivrayi* and *E. roratus solomonensis* are deep blue. It is in CITES list of vulnerable species (Forshaw, 2010).

Figure 27. *E. roratus*' male and female chicks (by John Donahue).

Figure 28. *E. roratus*' male adult (by Mehd Halaouate).

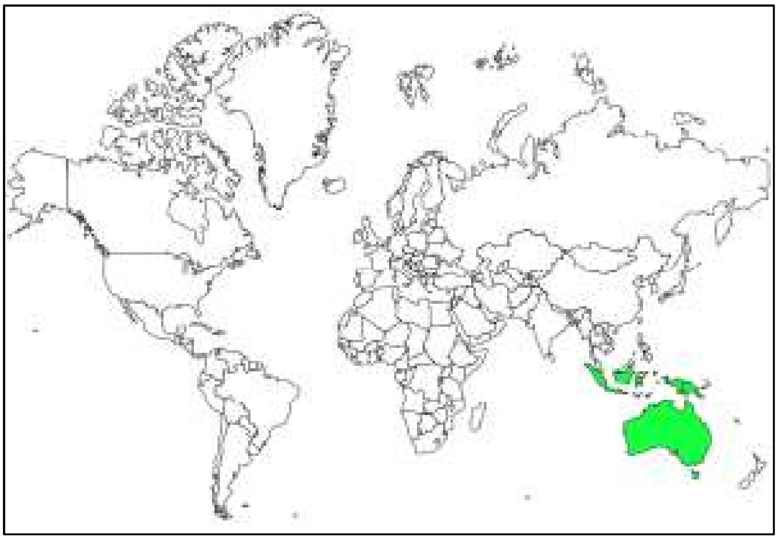

Figure 29. *E. roratus*' distribution in the world (http://www.oiseaux.net).

EOLOPHUS ROSEICAPILLA

Eolophus roseicapilla, also known as Rose-breasted Cockatoo, is a midsized pink and gray cockatoo (about 35cm and 360gr) with short, recumbent crest (Figures 30 and 31). Displays sexual dimorphism with males having a dark-brown iris and females a pink-red iris. Juveniles can be recognized by its pale-brown iris**.** This bird feeds mostly on the ground. Lives in ubiquitous family groups or large flocks. *E. roseicapilla* can be found in Australia (Figure 32). There are three subspecies: *E. roseicapilla roseicapilla*; *E. roseicapilla albiceps* and *E. roseicapilla kuhli*. It is in CITES list of vulnerable species (Forshaw, 2010).

Figure 30. *E. roseicapilla*'s chicks (by Diana Andersen).

Figure 31. *E. roseicapilla*'s adult (by Cheryl Moore).

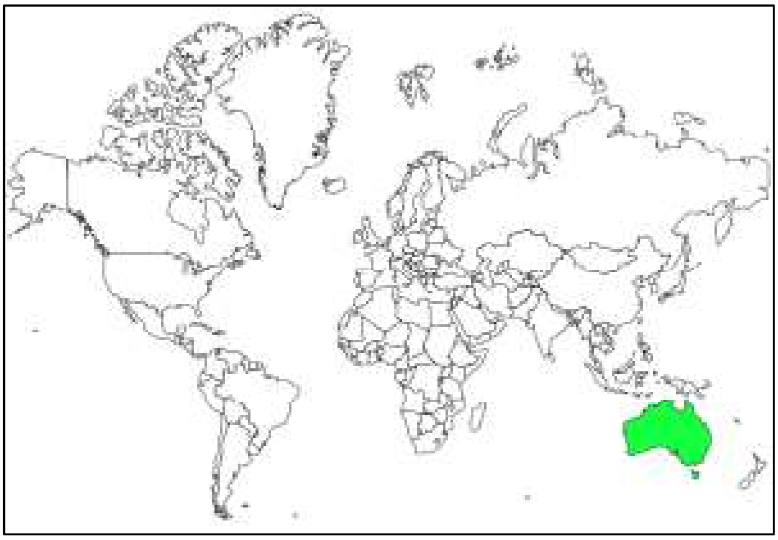

Figure 32. *E. roseicapilla*'s distribution in the world (http://www.oiseaux.net).

NESTOR NOTABILIS

Nestor notabilis, also known as Kea, is a large stocky parrot (about 48cm and 950gr) with narrow projecting bill and short square-like tail (Figures 33 and 34). Displays no sexual dimorphism and juveniles resemble adults**.** This bird feeds mostly on the ground and is omnivore feeding from plants, beetles, other birds and mammals. Lives in pairs or small groups. *N. notabilis* can be found in New Zealand from Fiordland north to Nelson and Marlborough province (Figure 35). It is in CITES list of vulnerable species (Forshaw, 2010).

Figure 33. *N. notabilis*' chick (by Kirsty Swinnerton).

Figure 34. *N. notabilis*' adult (by Ron Hoff).

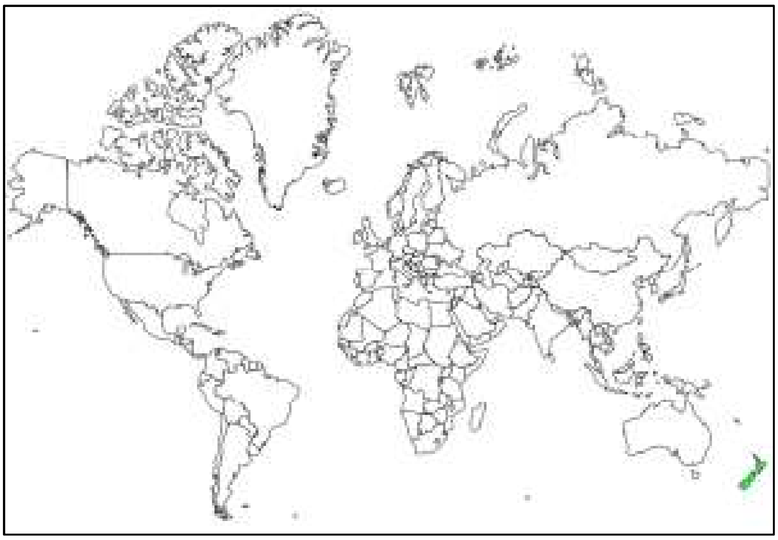

Figure 35. *N. notabilis*' distribution in the world (http://www.oiseaux.net).

PIONITES LEUCOGASTER

Pionites leucogaster, also known as White-bellied Caique, is a small sized parrot (about 23cm and 165gr) with short, square-like tail and fairly short, rounded wings (Figures 36 and 37). Displays no sexual dimorphism and juveniles have usually dimmer colors than adults. This bird is arboreal and lives in pairs or in small flocks. *P. leucogaster* can be found in southern Amazon and south of Amazon River (Figure 38). There are three subspecies: *P. leucogaster leucogaster*; *P. leucogaster xanthurus* and *P. leucogaster xanthomeria*. It is in CITES list of vulnerable species (Forshaw, 2010).

Figure 36. *P. leucogaster*'s chicks (by Gail J. Worth).

Figure 37. *P. leucogaster*'s adult (by Steve Milpacher).

Figure 38. *P. leucogaster*'s distribution in the world (http://www.oiseaux.net).

POICEPHALUS ROBUSTUS

Poicephalus robustus, also known as Cape Parrot, is a midsized stocky parrot (about 33cm and 300gr) and the largest *Poicephalus* parrot, with short, square-like tail and stout bill (Figures 39 and 40). Displays slight sexual dimorphism and juveniles have usually dimmer colors than adults. This bird is mostly arboreal and lives in pairs, small or large groups. *P. robustus* can be found in southern and west Central Africa (Figure 41). There are three subspecies: *P. robustus robustus*; *P. robustus suahelicus* and *P. robustus fuscicollis*. It is in CITES list of vulnerable species (Forshaw, 2010).

Figure 39. *P. robustus*' chicks (by Craig Harris).

Figure 40. *P. robustus*’ adult (by Ciryl Laubscher).

Figure 41. *P. robustus*’ distribution in the world (http://www.oiseaux.net).

PRIMOLIUS COULONI

Primolius couloni, also known as Blue-headed Macaw, is a midsized (about 43cm and 240gr) green macaw with blue head and blue tipped red tail (Figure 42). Displays no sexual dimorphism and juveniles have usually dimmer colors than adults. This bird is arboreal and lives in pairs or in small flocks. *P. couloni* can be found in eastern Peru, south from Rio Huallaga valley, Loreto and westernmost Brazil (Acre), to northern Bolivia and east Andes (Figure 43). It is in CITES list of critically endangered species (Forshaw, 2010).

Figure 42. *P. couloni*'s adult (by Anthony Snell)

Figure 43. *P. couloni*'s distribution in the world (http://www.oiseaux.net).

PSITTACUS ERITHACUS

Psittacus erithacus, also known as African Grey Parrot, is a large stocky parrot (about 33cm and 350gr) with short square-like red tail (Figures 44 and 45). Displays no sexual dimorphism and juveniles resemble adults. This bird is arboreal and lives in groups. *P. erithacus* can be found in west and central Africa (Figure 46). There are two subspecies: *P. erithacus erithacus* and *P. erithacus timneh*. It is in CITES list of vulnerable species (Forshaw, 2010).

Figure 44. *P. erithacus*'s chick (by Steve Milpacher).

Figure 45. *P. erithacus*'s chick (by Jamie Gilardi).

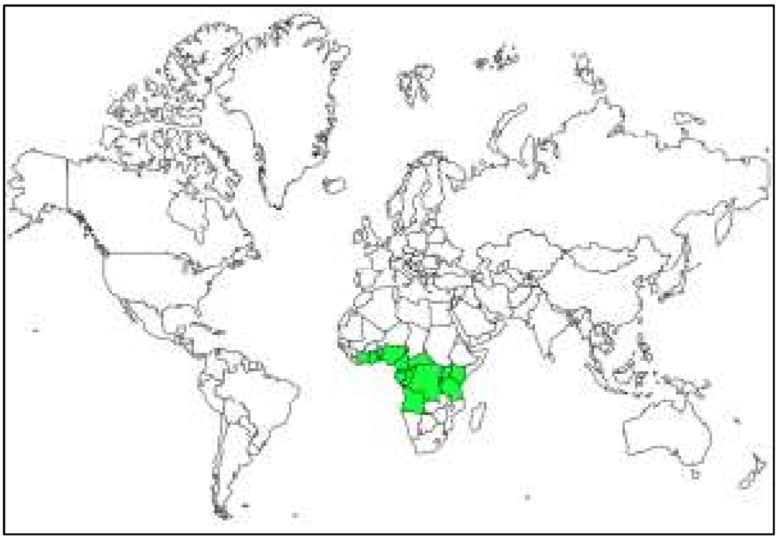

Figure 46. *P. erithacus*'s distribution in the world (http://www.oiseaux.net).

PYRRHURA PERLATA

Pyrrhura perlata, also known as Crimson-bellied Conure, is a small sized parrot (about 24cm and 85gr) with crimson abdomen and prominent white eye-ring (Figures 47 and 48). Displays no sexual dimorphism and juveniles have usually a green abdomen with or without red markings. This bird is arboreal and lives in small groups. *P. perlata* can be found in central and southern Amazon River, northern Brazil and northern Bolivia (Figure 49). It is in CITES list of vulnerable species (Forshaw, 2010).

Figure 47. *P. perlata*'s chicks (by Gail J. Worth).

Figure 48. *P. perlata*'s adult (by Steve Brooks).

Figure 49. *P. perlata*'s distribution in the world (http://www.oiseaux.net).

TRICHOGLOSSUS HAEMATODUS

Trichoglossus haematodus, also known as Rainbow Lorikeet, is a small to midsized parrot (about 26cm and 120gr), with graduated tails and orange bills (Figures 50 and 51). Displays no sexual dimorphism and juveniles resemble adults. This bird is arboreal and lives pairs or large groups. *T. haematodus* can be found in Bali and islands in Flores sea, east through south Moluccas and lesser Sunda islands, New Caledonia and Loyalty islands and northern and eastern Australia (Figure 52). There are up to twenty slightly differentiated to well-marked subspecies: *T. haematodus haematodus*; *T. haematodus rosenbergii*; *T. haematodus micropteryx*; *T. haematodus caeruleiceps*; *T. haematodus nigrogularis*; *T. haematodus nesophilus*; *T. haematodus flavicans*; *T. haematodus massena*; *T. haematodus deplanchii*; *T. haematodus mollucanus*; *T. haematodus septentrionalis*; *T. haematodus rubritorquis*; *T. haematodus flavotectus*; *T. haematodus capistratus*; *T. haematodus fortis*; *T. haematodus weberi*; *T. haematodus* *forsteni*; *T. haematodus mitchellii*; *T. haematodus djampeanus* and *T. haematodus stresemanni*. It is in CITES list of vulnerable species (Forshaw, 2010).

Figure 50. *T. haematodus*'s chick (by Amy Eatts).

Figure 51. *T. haematodus*'s adult (by Steve Milpacher).

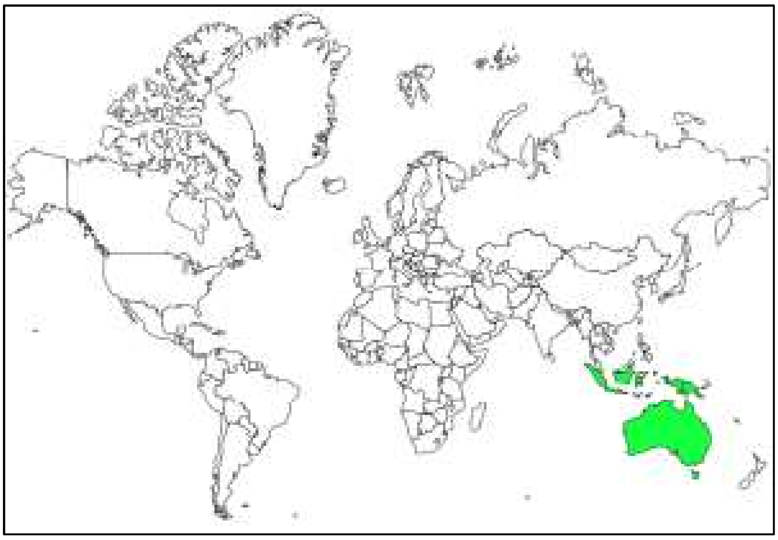

Figure 52. *T. haematodus*'s distribution in the world (http://www.oiseaux.net).

Because the existing information on what is the expected weight gain/day of a psittacine newborn is limited, the main goal of present thesis was to determine the standard value of psittacine growth, by answering the question “What is the standard value of weight gain/day in selected species of psittacines?”

It is important to notice that the results obtained with this study may not be reflected in nature. Captive breeding conditions are not subjected to as many variables as those found in the wild. It is also important to distinguish between captivity chicks raised in artificial conditions (i.e. LP's BS) or raised in natural conditions (i.e. individuals kept in the nest and fed by parents) as both scenarios have different variables.

This study is of utmost importance for veterinarians, breeders, keepers and pet owners all over the world. The availability of data with what are considered the standard values of growth for certain species will give a guideline to what is the expected growth rate of a psittacine chick and supply a reliable framework for those interested in pediatric psittacine health.

MATERIAL AND METHODS

The data collected for the present study was obtained from all chicks born at Loro Parque, in the incubator or in the nest, between January 2011 and December 2011. A total of 527 animals were enrolled in this work. All psittacines lived in cages that mimic their natural environment. Oviposition was done in the nest. After that, eggs were carefully collected and placed inside incubators. If eggs happen to hatch in the nest, young chicks were then taken to BS.

Although visitors can see inside Loro Parque's BS, they are not allowed to go inside. All staff has to wear a clean lab coat and sterile gloves when working in BS.

As a daily routine, neonates were the first to be manipulated, in order to prevent contamination from older birds. They were cleaned, weighted and fed. The same method was applied in all other birds. Individual data collected included weight/day, health status (body score: thin, ideal and obese, temperature, mucosa coloration, feces consistency and color), medical treatment (if necessary) and information on survival (dead or alive). Weight was obtained, once a day, on a precision scale (A&D EJ6100), with an error of plus or minus 0.005g.

Although other studies use additional biometric parameters such as tarsal, beak and/or wing length to evaluate chick growth, their measurement can sway depending on the handler. Weigh measurement is objective and easy to obtain, requiring a scale and minimum manipulation.

The 527 birds used in this study were classified by LPF's curator, according to the current taxonomy classification into species and subspecies. A total of 115 species and 37 subspecies were identified. A total of 16.996 weights were recorded.

Two different records were obtained. The first included animals hatched in the incubator. These animals were weighted from day one until the day they were apt to leave the BS (*fledgling*). The second record included animals hatched in the nest. Once retrieved from the nest the handler would calculate how many days old the chick was with an error of plus or minus 48 hours. Weight records for these animals started on the day they were taken from the nest to BS. For example, if the newborn was taken from the nest with four days of age its weight record would start on day four and not day one.

The statistical analysis was applied to a sample of 296 animals belonging to 15 species, with a total of 10.884 weight measurements. For the descriptive analysis SPSS/PASW 20 IBM was used. Standard deviation, mean weight in grams by day and a 95% confidence interval (CI) was determined. These data were used to obtain the growth curves in Microsoft Excel 2010.

Being innovative, the proposed study could not be a comparative one. It can be described as a census of the whole population and not a sample of it, therefore, a higher number of individuals (N) represents a lower variability between weights. It was determined that N=8 was the minimum of individuals needed to reduce variability between weights.

The inclusion criteria was all psittacines born in Loro Parque, between January 2011 and December 2011, which remained healthy (referred as *healthy* from now on) during the measurement period. The exclusion criteria were:

i) individuals that became sick during the measurement period (referred as *sick* from now on);
ii) animals that died during the measurement period;
iii) species that had less than 8 individuals during the measurement period.

Animals were considered sick when they presented abnormal signs such as: pallor, ascites, low body condition (LBC), edema, diarrhea, crop stasis, lethargy, omphalitis, yolk sac retention (YSR), beak trauma or regurgitation.

As referred, initial records were divided in nest-born and incubator-born individuals. Because most individuals from the same species divided by *nest* and *incubator* did not fulfill the requirement of a minimum of 8 individuals per species), all weights were analysed together, disregarding their origin.

Because *nest-born* and *incubator-born* animals were analyzed together, the number of animals weighted changed over time. For example, if species A had 5 *incubator* chicks, mean weight from 5 individuals would be obtained from day 1. If at day 4 three *nest* chicks from species A were introduced in the study, a mean weight of 8 would be obtained from then on.

Time is measured in days after hatching and not the actual date of birth, therefore, the number of individuals analysed by day remains constant.

When stratifying the selected individuals into healthy and sick groups, it was noticed that some *healthy* individuals were later declared dead. In those cases, those animals were considered *sick*. All animals that were considered sick were excluded from the statistical analysis.

Measurements of 231 birds were excluded because they did not meet the criteria described above.

A chick was considered apt to leave the BS when it finished the first molt and was able to eat and drink by itself. Once moved outside BS, its weight record ceased. Fledging changes significantly between species and subspecies, between individuals of the same species and, in this case, on the subjective evaluation of the keeper. Usually, smaller species fledge earlier than larger ones.

Classification between males and females is done after weaning. Therefore, gender was not taken into account in this study.

Chicks were fed Nutribird A19 formula until they were able to eat and drink for themselves. Introduction of vegetables, small nuts and fruits was made when the chick was at two assisted feedings a day. Because of their particular nutritional needs, lories were fed Nutribird A18 and members of the *Cacatuoidea* superfamily were fed Nutribird A 21.

When the graphics of all weight curves were obtained, it was observed that two curves eloped from the pattern obtained in the other graphics. An assessment of the data was necessary and, at this point, it was possible to determine that, although at the beginning of the study all species considered had an N ≥ 8, after application of the exclusion criteria this number diminished.

RESULTS

The weight measurements were performed on 527 animals that belonged to 115 species and 37 subspecies as described in Table 1.

Table 1. Psittacine identification and number of individuals (n) examined.

Species	Subspecies	n
Amazona albifrons	*nana*	2
Amazona albifrons		4
Amazona amazonica		2
Amazona autumnalis	*autumnalis*	1
Amazona autumnalis	*lilacina*	1
Amazona barbadensis		7
Amazona farinosa		1
Amazona festiva	*bodini*	4
Amazona finschi		6
Amazona ochrocephala	*auropalliata*	2
Amazona ochrocephala	*panamensis*	1
Amazona oratrix	*tresmariae*	2
Amazona oratrix		4
Amazona panamensis		1
Amazona pretrei		3
Amazona vinacea		9
Amazona viridigenalis		6
Amazona xantholora		1
Anadorhynchus hyacinthinus		2
Ara ambigua		2
Ara ararauna		1
Ara auricollis		1
Ara chloroptera		4
Ara couloni		1
Ara glaucogularis		20
Ara macao		2
Ara maracana		1
Ara militaris		1
Ara nobilis		4
Ara rubrogenys		6
Ara severa		2
Aratinga canicularis		4
Aratinga pertinax		1
Aratinga solstitialis		21

Table 1. Psittacine identification and number of individuals (n) examined (cont).

Species	Subspecies	n
Aratinga finschi		2
Aratinga suriname		2
Aratinga weddellii		2
Brotogeris tirica		4
Cacatua alba		1
Cacatua ducorpsii		8
Cacatua galerita	*eleonora*	9
Cacatua galerita	*triton*	4
Cacatua leadbeateri		6
Cacatua moluccensis		2
Cacatua ophtalmica		4
Cacatua sanguinea		6
Cacatua sulphurea	*citrinocristata*	2
Cacatua triton		4
Chalcopsitta duivenbodei		4
Chalcopsitta scintillata		4
Charmosyna papou		10
Deroptyrus accipitrinus	*fuscifrons*	2
Deroptyrus accipitrinus		4
Eclectus roratus	*polychlorus*	14
Eclectus roratus	*roratus*	10
Eclectus roratus	*solomonensis*	1
Eclectus roratus	*redeli*	1
Eolophus roseicapilla		9
Eos bornea		1
Eos histrio		1
Eos reticulata		2
Eos semilarvata		2
Eos squamata		4
Guarouba guarouba		4
Loriculus philippensis		1
Loriculus vernalis		3
Lorius domicellus		1
Lorius hypoinochrous	*devittatus*	7
Lorius lori		1
Nestor notabilis		10
Pezoporus occidentalis		1
Phigys solitarius		2
Pionites leucogaster	*leucogaster*	3
Pionites leucogaster	*xanthomeria*	9

Table 1. Psittacine identification and number of individuals (n) examined (cont).

Species	Subspecies	n
Pionites melanocephalus		3
Pionopsitta pileata		5
Pionus chalcopterus		5
Pionus maximiliani		3
Pionus seniloides		4
Pionus tumultuosus		5
Poicephalus robustus	*fuscicollis*	8
Poicephalus robustus	*robustus*	4
Poicephalus senegalus		6
Polytelis swainsonii		1
Primolius couloni		10
Probosciger aterrimus		2
Pseudeos fuscata		2
Psittacula alexandri	*abotti*	1
Psittacula alexandri		1
Psittacula eupatria		2
Psittacus erithacus	*erithacus*	10
Psittacus erithacus	*timneh*	9
Psitteuteles goldiei		1
Psittrichas fulgidus		1
Pyrrhura molinae	*hypoxantha*	4
Pyrrhura perlata	*coerulescens*	11
Pyrrhura perlata	*lepida*	3
Pyrrhura perlata	*perlata*	29
Pyrrhura picta	*roseifrons*	4
Pyrrhura rodocephala		2
Tanygnathus sumatranus		2
Trichoglossus euteles		2
Trichoglossus haematodus	*caeruleiceps*	5
Trichoglossus haematodus	*capistratus*	4
Trichoglossus haematodus	*deplanchii*	5
Trichoglossus haematodus	*forsteni*	3
Trichoglossus haematodus	*haematodos*	7
Trichoglossus haematodus	*moluccanus*	40
Trichoglossus haematodus	*rosenbergii*	5
Trichoglossus haematodus	*rubritorchis*	4
Trichoglossus johnstoniae		2
Trichoglossus ornatus		7
Triclaria malachitacea		1
Vini australis		7
Total		527

For statistical analysis only the weight measurements of species with a minimum number of 8 individuals were used. Smaller groups were excluded from the present analysis. Since few subspecies fulfilled this requirement, subspecies were grouped into their species classification. Table 2 represents the total of psittacines by species analysed, from the *incubator* and the *nest*.

Table 2. Total of psittacines by species used for the statistical analysis of weight gain/day.

Species	n
Amazona vinacea	9
Ara glaucogularis	20
Aratinga solstitialis	21
Cacatua ducorpsii	8
Cacatua galerita	13
Charmosyna papou	10
Eclectus roratus	26
Eolophus roseicapilla	9
Nestor notabilis	10
Pionites leucogaster	12
Poicephalus robustus	12
Primolius couloni	11
Psittacus erithacus	19
Pyrrhura perlata	43
Trichoglossus haematodus	73
Total	296

From the statistical analysis of the weight measurements by species, a total of 15 curves were obtained. The data used to drawn the growth curves are presented in Tables 4 to 18, in appendix 1. These represent mean growth curves and both upper and lower confidence interval (CI) curves (Figures 1 to 15). These curves represent all healthy animals from the selected population.

Figure 53 represents the weights for *Amazona vinacea* from hatching day (day one) to the last day on baby station (day 41). No new specimens from the nest were added during this period of time.

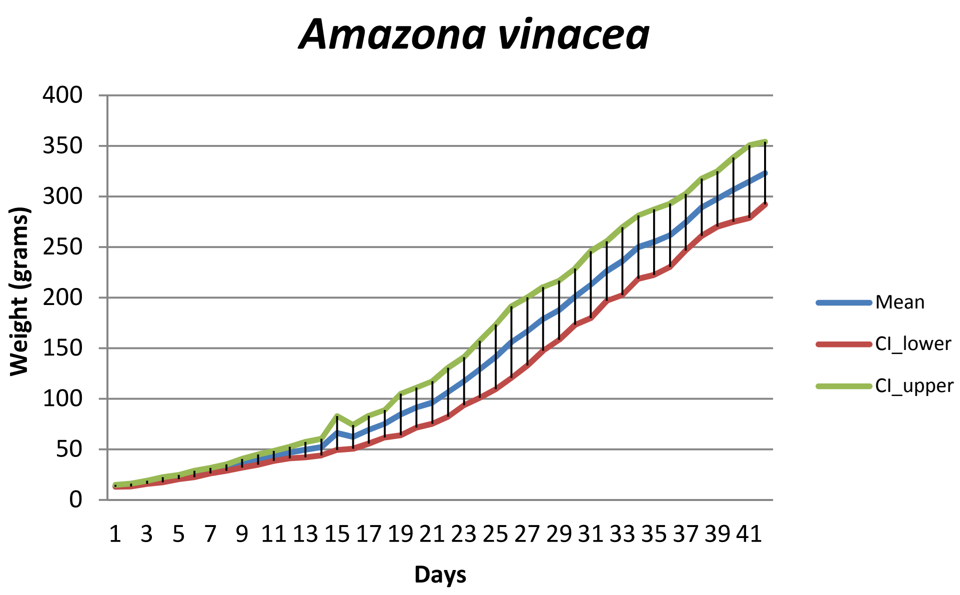

Figure 53. *Amazona vinacea*'s mean weight curve, upper CI curve and lower CI curve. No new specimens from the nest were added during this period of time. N=5.

Figure 54 represents the weights for *Ara glaucogularis* from hatching day (day one) to the last day on baby station (day 85). From day 52 to day 85 some individuals reached their independence and left BS. No new specimens from the nest were added during this period of time.

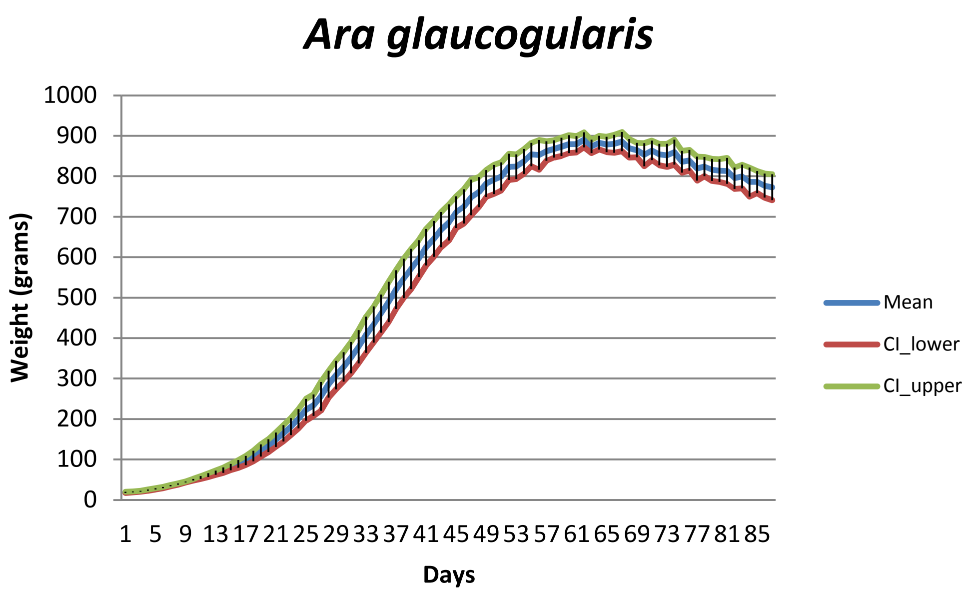

Figure 54. *Ara glaucogularis*' mean weight curve, upper CI curve and lower CI curve. No new specimens from the nest were added during this period of time. N=16.

Figure 55 represents the weights for *Aratinga solstitialis* from hatching day (day one) to the last day on baby station (day 41). New specimens from the nest were added after the 12th day.

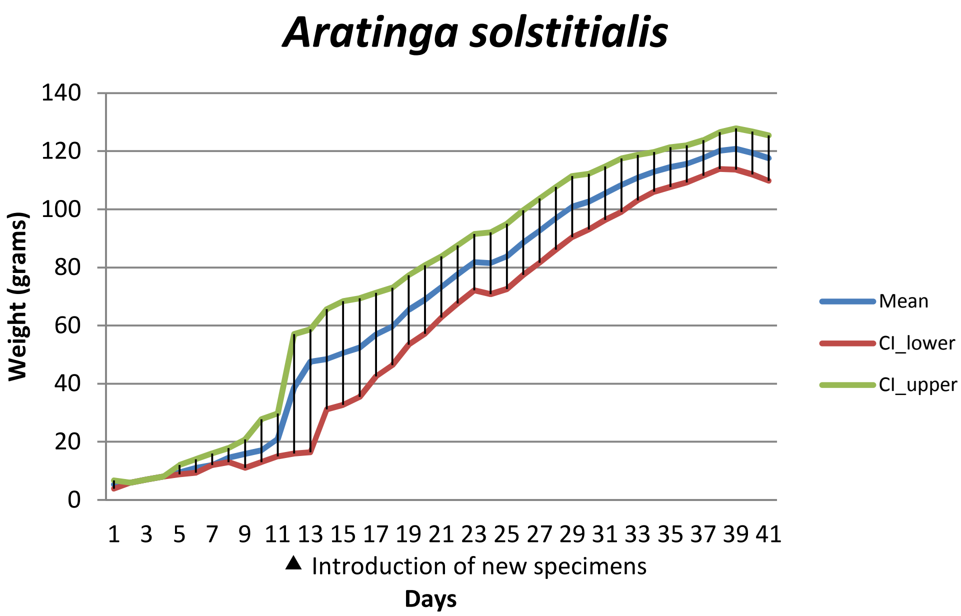

Figure 55. *Aratinga solstitialis*' mean weight curve, upper CI curve and lower CI curve. New specimens from the nest were added at day 12 (N=3), day 13 (N=5), day 14 (N=7), day 16 (N=8), day 17 (N=9), day 18 (N=20), day 19 (N=21), day 21 (N=22) and day 24 (N=23).

Figure 56 represents the weights for *Cacatua ducorpsii* from hatching day (day one) to the last day on baby station (day 49). No new specimens from the nest were added during this period of time.

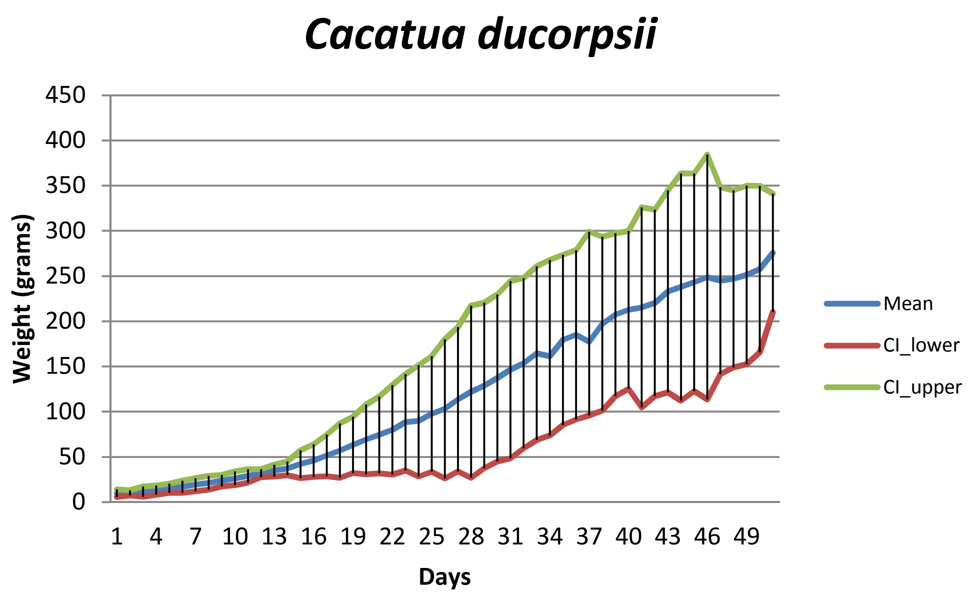

Figure 56. *Cacatua ducorpsii*'s mean weight curve, upper CI curve and lower CI curve. No new specimens from the nest were added during this period of time. N=3

Figure 57 represents the weights for *Cacatua galerita* from hatching day (day one) to the last day on baby station (day 49). No new specimens from the nest were added during this period of time.

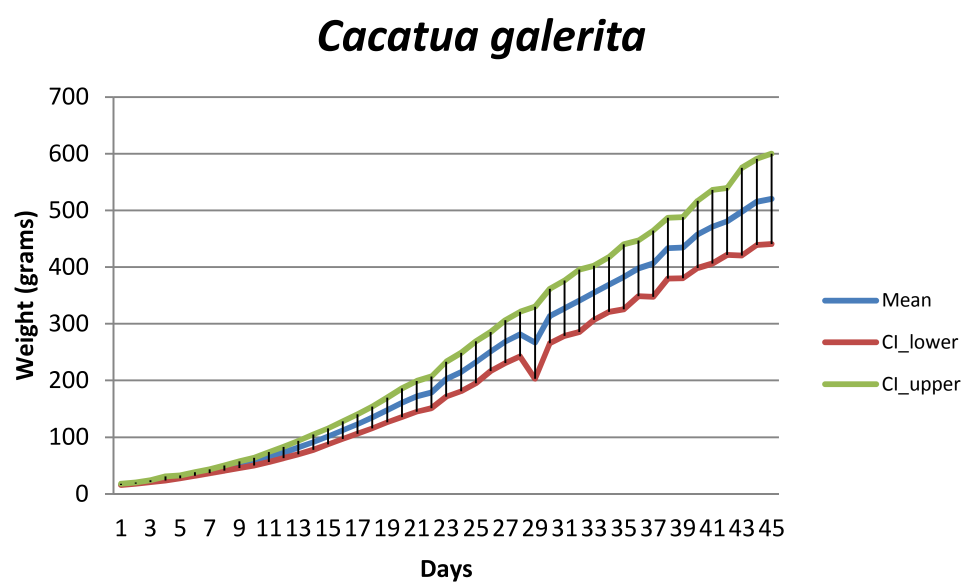

Figure 57. *Cacatua galerita*'s mean weight curve, upper CI curve and lower CI curve. No new specimens from the nest were added during this period of time. N=14.

Figure 58 represents the weights for *Charmosyna papou* from hatching day (day one) to the last day on baby station (day 41). New specimens from the nest were added at the second day.

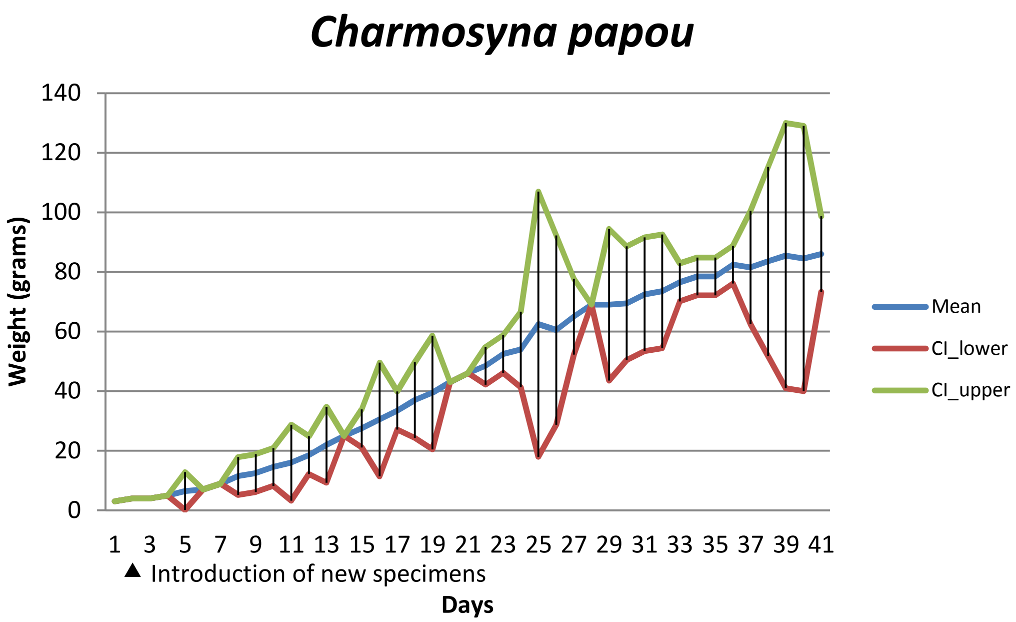

Figure 58. *Charmosyna papou*'s mean weight curve, upper CI curve and lower CI curve. New specimens from the nest were added at day 2 (N=2).

Figure 59 represents the weights for *Eclectus roratus* from hatching day (day one) to the last day on baby station (day 49). New specimens from the nest were added at the 13th day.

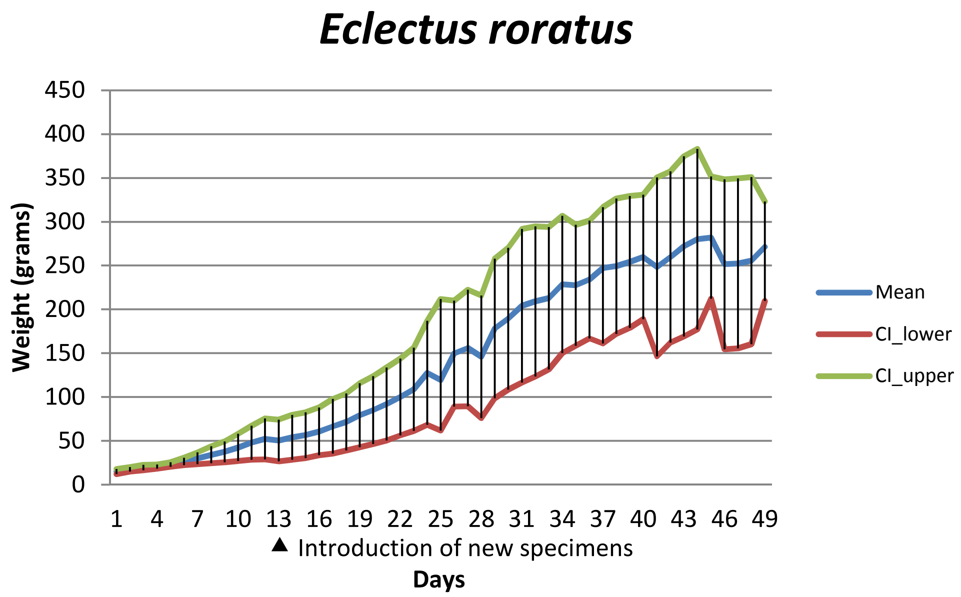

Figure 59. *Eclectus roratus*' mean weight curve, upper CI curve and lower Ci curve. New specimens from the nest were added at day 13 (N=6).

Figure 60 represents the weights for *Eolophus roseicapilla* from hatching day (day one) to the last day on baby station (day 69). No new specimens from the nest were added during this period of time.

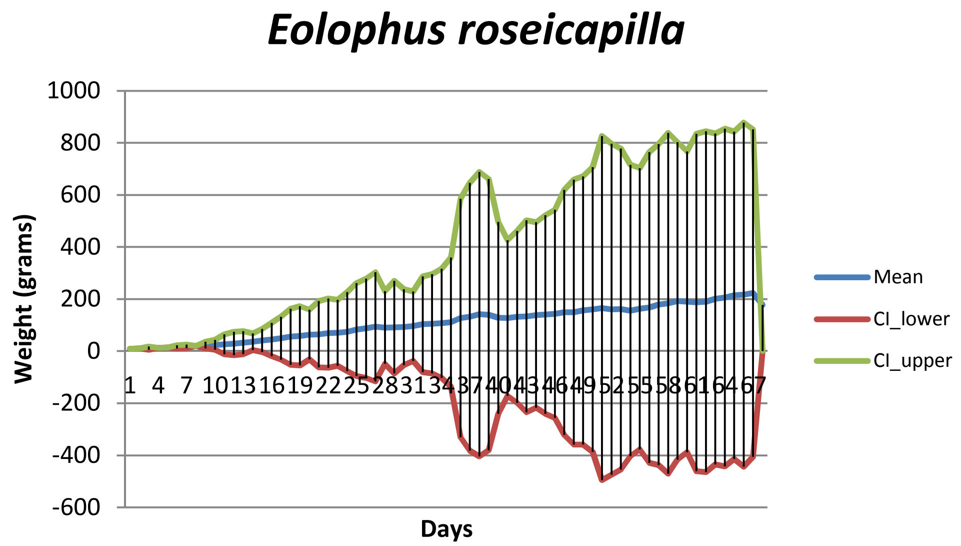

Figure 60. *Eolophus roseicapilla*'s mean weight curve, upper CI curve and lower CI curve. No new specimens from the nest were added during this period of time. N=2.

Figure 61 represents the weights for *Nestor notabilis* from hatching day (day one) to the last day on baby station (day 25). No new specimens from the nest were added during this period of time.

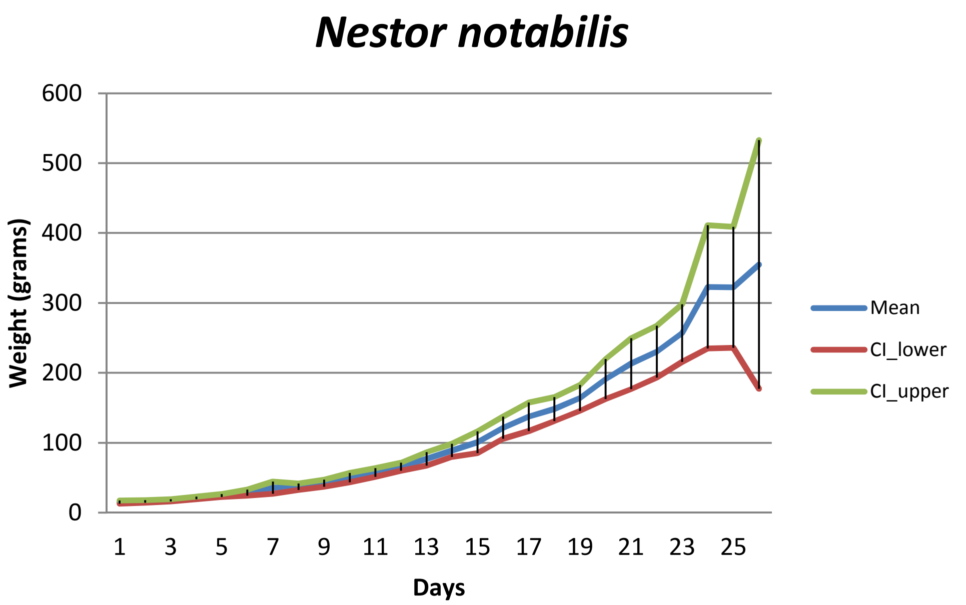

Figure 61. *Nestor notabilis*' mean weight curve, upper CI curve and lower CI curve. No new specimens from the nest were added during this period of time. N=5.

Figure 62 represents the weights for *Pionites leucogaster* from the first record (day seven) to the last day on baby station (day 43). All specimens were from the nest.

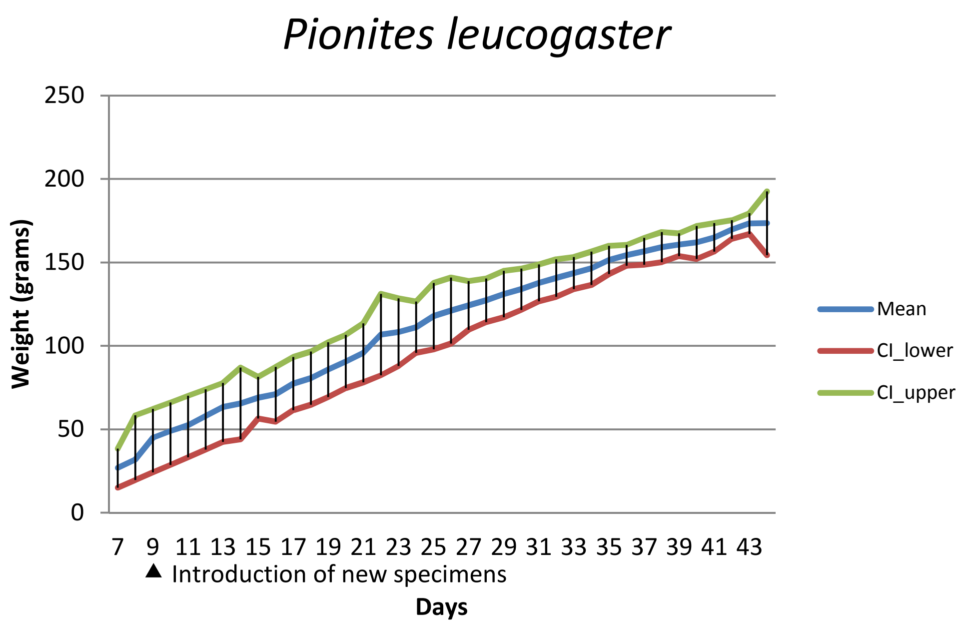

Figure 62. *Pionites leucogaster*'s mean weight curve, upper CI curve and lower CI curve. All specimens are from the nest. N=1 at day 7, N=2 at day 9, N=3 at day 12, N=4 at day 14, N=5 at day 15 and N=6 from day 16.

Figure 63 represents the weights for P*oicephalus robustus* from the first record (day thirteen) to the last day on baby station (day 54). All specimens were from the nest.

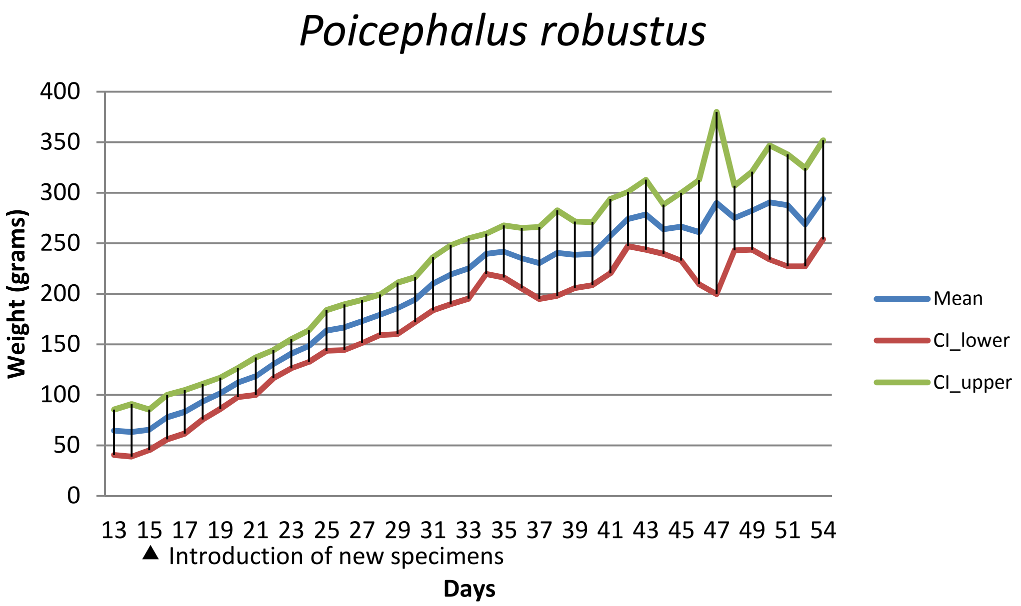

Figure 63. *Poicephalus robustus*' mean weight curve, upper CI curve and lower CI curve. All specimens are from the nest. N=2 at day 13, N=4 at day 15, N=6 at day 16, N=7 at day 18 and N=9 from day 20.

Figure 64 represents the weights for *Primolius couloni* from hatching day (day one) to the last day on baby station (day 41). New specimens from the nest were added at the 9th day.

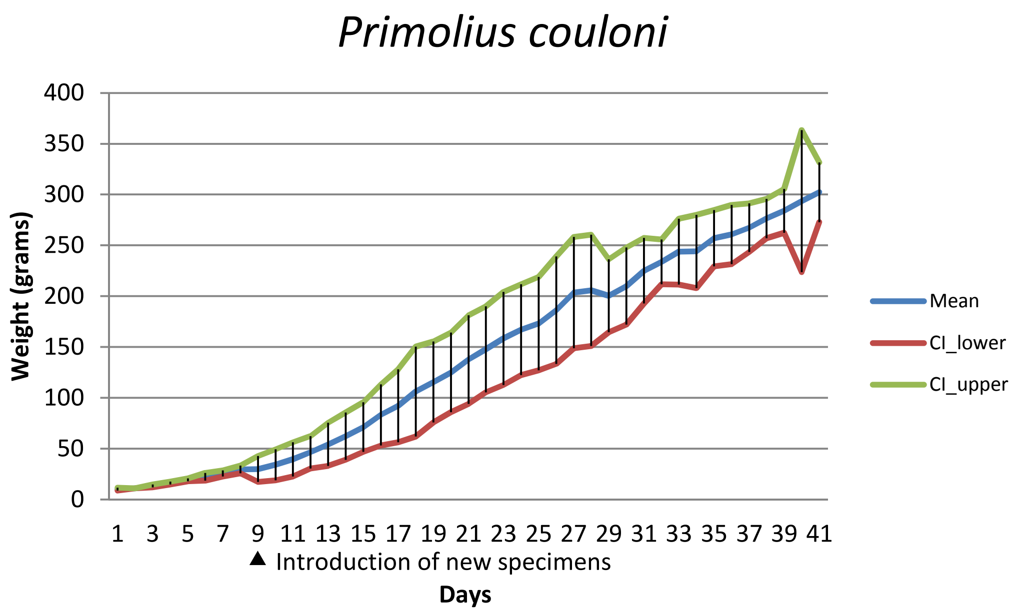

Figure 64. *Primolius couloni*'s mean weight curve, upper CI curve and lower CI curve. New specimens from the nest were added at day 9 (N=4).

Figure 65 represents the weights for *Psittacus erithacus* from hatching day (day one) to the last day on baby station (day 49). No new specimens from the nest were added during this period of time.

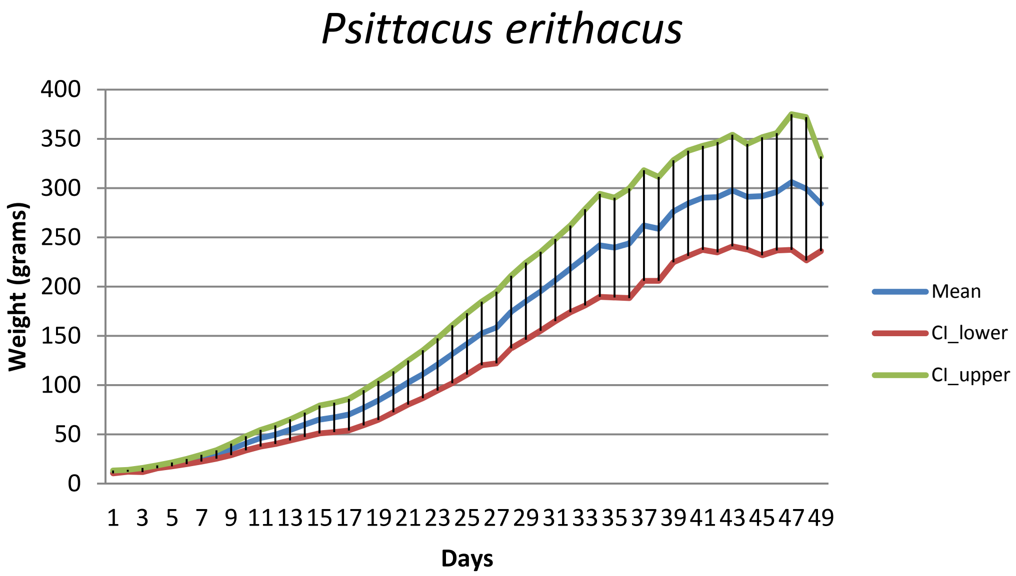

Figure 65. *Psittacus erithacus*' mean weight curve, upper CI curve and lower CI curve. No new specimens from the nest were added during this period of time. N=15.

Figure 66 represents the weights for *Pyrrhura perlata* from the first record (day nine) to the last day on baby station (day 39). All specimens were from the nest.

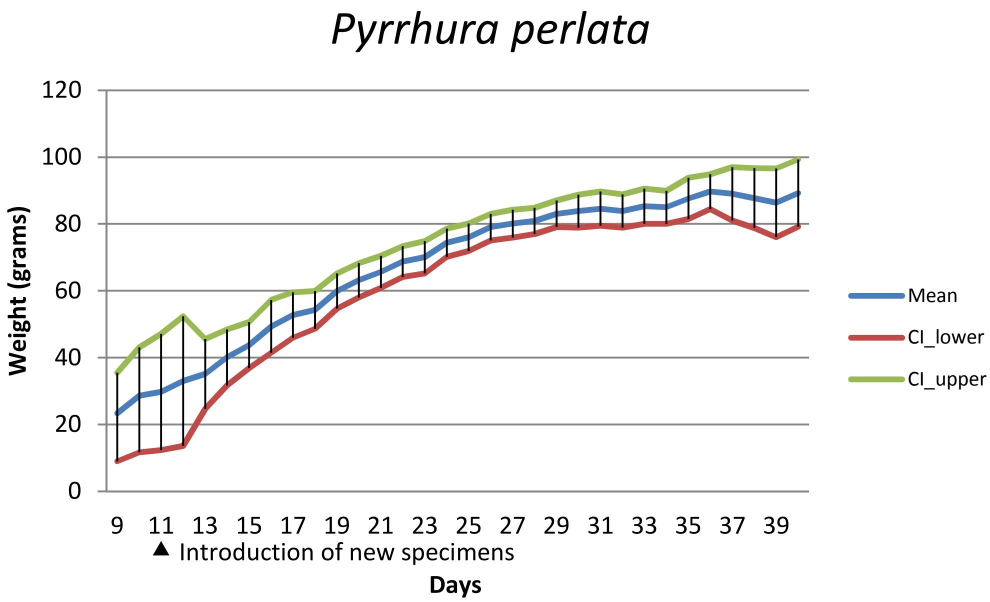

Figure 66. *Pyrrhura perlata*'s mean weight curve, upper CI curve and lower CI curve. All specimens are from the nest. N=3 at day 9, N=4 at day 11, N=7 at day 13, N=11 at day 14, N=15 at day 15, N=17 at day 16, N= 19 at day 17, N=21 at day 18 and N=22 from day 19.

Figure 67 represents the weights for *Trichoglossus haematodus* from hatching day (day one) to the last day on baby station (day 57). New specimens from the nest were added after the 4th day.

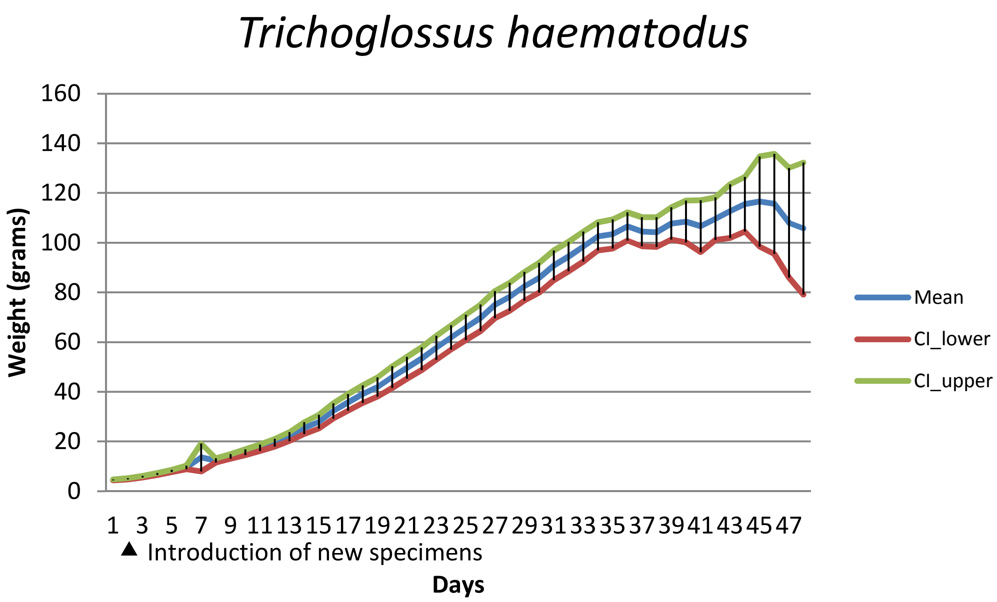

Figure 67. *Trichoglossus haematodus*' mean weight curve, upper CI curve and lower CI curve. New specimens from the nest were added at day 2 (N=43), day 5 (N=44), day 6 (N=45), day 10 (N=46), day 19 (N=50).

As previously stated, *sick* animals were excluded from the statistics. The data presented on Figures 68 and 69 represent the most common signs of disease in the studied population.

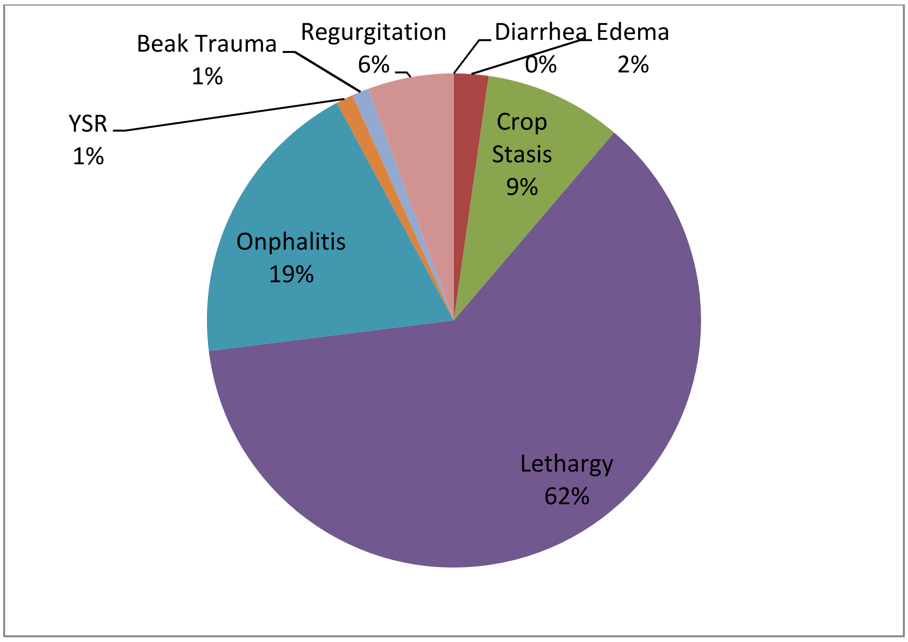

Figure 68. Signs of disease in the *sick* population.

From a total of 130 *sick* animals, the most common sign observed was lethargy (62%) followed by omphalitis (19%), crop stasis (9%), regurgitation (6%), edema (2%) and beak trauma (1%) and YSR (1%).

Lethargy was found in all species, being the only sign described in *Pyrrhura perlata* and *Cacatua galerita*. Omphalitis was present in six of the initial 15 species, with higher prevalence (48%) in *Eclectus roratus*. Crop stasis was the third most common sign being present in six species.

Eclectus roratus and *Eolophus roseicapilla* were the species with the higher heterogeneity, with six of the seven signs of diseases found in the *sick* population.

Figure 69 represents the most common signs found in each studied species.

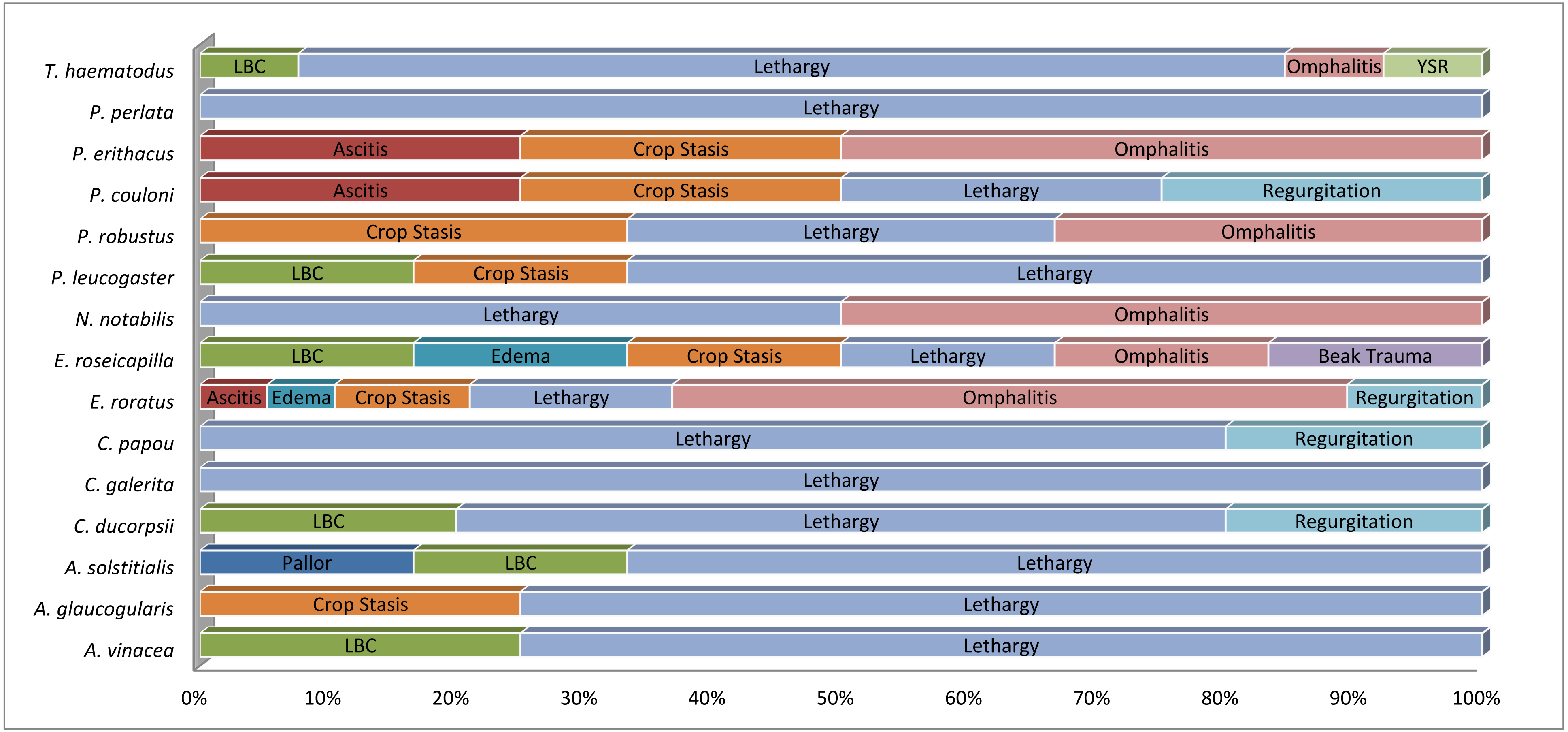

Figure 69. Common signs of disease by species.

DISCUSSION

GROWTH CURVES

The main goal of the present study was to determine the standard value of psittacine growth in a nursery from daily weight records of selected species.

The purpose of this study was achieved for the species *Ara glaucogularis*, *Aratinga solstitialis*, *Cacatua galerita*, *Poicephalus robustus*, *Psittacus erithacus*, *Pyrrhura perlata* and *Trichoglossus haematodus*, as representative growth curves were obtained.

A minimum number of eight individuals were used to obtain the weight curves. Table 1 represents the total number of individuals weighted, classified by species and subspecies. Because the N obtained using the subspecies classification was inferior to eight, individuals were classified and grouped according only to their species (Table 2).

A total of 15 species with more than eight individuals were selected in a total of 296 animals, that is to say, 56.16% of the initial sample (Table 2). These included *sick* and *healthy* individuals. So, as to obtain standardized growth curves of healthy animals, the inclusion criterion *healthy* was used. Therefore all *sick* individuals were excluded.

Curves from Figure 58 (*Charmosyna papou*) and Figure 60 (*Eolophus roseicapilla*) eloped from the pattern observed in the other curves. When assessing the database, it was verified that for *Charmosyna papou* and *Eolophus roseicapilla,* after excluding all *sick* individuals, the number of animals was less than eight.

With this new consideration, an assessment of all the selected species was made. It was observed that other species had $N < 8$ even though their growth curves followed the expected pattern reported by Ricklefs (1973): Figure 56 with $N=3$; Figure 64 with $N=4$; Figures 53 and 61 with $N=5$; Figures 59 and 62 with $N=6$.

When $N<3$ (Figures 58 and 60) both upper and lower CI withdraw from the media line, decreasing the confidence of the results. The same singularity was observed in the end of some curves where $N \geq 8$. (Figures 54, 55, 57, 63, 65, 66 and 67) This can be explained with the decreasing number of individuals being monitored as a consequence of the weaning process (being able to eat and drink by themselves thus leaving BS).

When $3<N<8$ (Figures 53, 59, 62 and 64) it was observed an increased confidence of the results. Visually, the amplitude of both upper and lower CI stays close to the media line. To further explore this element and distinguish fluke from pattern it would be necessary to use a larger sample.

When N>8 (Figures 54, 55, 57, 63, 65, 66 and 67) both upper and lower CI stay close to the media line, increasing the confidence of the results. These are in conformity with what was expected (Ricklefs, 1973).

When all chicks come solely from the *nest* (Figures 62, 63 and 66), the CI withdraws from the media line, converging as days go by. Since variables such as temperature, humidity, feeding quantity and frequency are not controlled in the nest, chicks with the same age have different weights. Once under controlled circumstances their weight tends to converge, thus the line pattern.

Figures 53, 57, 63 and 67 present sudden and transitory peaks in the CI curves. Such variations are interpreted as consequence of human error, one of the risk factors identified earlier. During the weighting process there were occasional aleatory weight omissions with no apparent explanation.

Figures 55 and 59 present sudden peaks in the CI curves that tend to converge over the time. These variations happen when weights from *nest* chicks are introduced in the daily measurements.

As for the species represented by Figures 57, 63, 65, 66 and 67, a deviance of IC amplitude was expected as a result of grouping several subspecies with different weight ranges.

The difference between the pattern obtained in Figure 59 and the other figures where 3<N<8, is explained by the heterogeneity of the studied individuals, since a division between subspecies was not possible and because this species has a marked sexual dimorphism, as males are usually larger than females.

The decreasing body weighty observed at the end of Figure 54 complies with Vigo (2010) study in *Ara macaw*'s chicks, were after a logarithmic growth phase, chicks slowly lost body weight until fledgling.

Other studies have been made to obtain standardized weights for nestling psittacines. Many are done on birds in the wild, estimating the days after the hatching and having little control over environmental and food variables (Ricklefs, 1973; Zach, 1984). Others collect weights from chicks in the wild and in captivity to compare differences in growth rates (Seixas & Mourão, 2003). Some authors on neonatology used Flammer & Clubb (1997) table for suggested weight gain in selected species.

It was possible to compare the values obtained for *Psittacus erithacus* and *Cacatua galerita* with those published by Flammer & Clubb (1997). Values for both species are in conformity with those described by these authors. Because there is no data on the growth pattern of the remaining species, to access *Ara glaucogularis*, *Aratinga solstitialis*, *Poicephalus robustus*, *Pyrrhura perlata* and *Trichoglossus haematodus* data, a comparison had to be made between species whose growth patterns were already studied. It was important to understand if the origin of the animals (wild *vs* captivity) was of any relevance. If not, a comparison between curves obtained in the wild and in captivity could be made. Growth curves from Seixas (2003) demonstrated that there were no great variations between growth patterns of psittacines of the same species raised in the wild or in captivity. Consequently, results from the mentioned species were in accordance with the literature (Ricklefs, 1973; Stoleson & Beissinger, 1996; Ricklefs, 1998; Konig, 2001; Masello & Quillfeldt, 2001; Renton, 2002; Seixas & Mourão, 2003; Pacheco *et al.,* 2010; Vigo *el al.,* 2010).

GROWHT AND DEVELOPMENT OF PSITTACINE CHICKS IN THE WILD

Although the present thesis uses data from individuals kept in strict captivity conditions, some similar studies used data collected in the wild. Such studies show how important variable control is and the impact that variables have in the growth of psittacine chicks.

Koenig (2001) aimed to identify what factors limited the reproduction and growth of *Amazona agilis* and *Amazona collaria* in Cockpit Country, Jamaica. Nest availability seemed to have no effect on *A. agillis* but was apparently of great importance to *A. collaria*. Growth rates variations appeared to be due to hatching asynchrony and not because of food resources reducing the frequency of daily feeding visits. Although first and second hatched were heavier than the third hatched, this disparity didn't affect the third chick survival. Starvation was common in brood of four as a result of unequal food distribution among siblings. Changes in temperature appeared to restrict the activity of the parents during the hottest part of the day and predation seemed to be the main factor limiting the reproduction of *A. agilis* (Koenig, 2001).

About the influence of environmental variability on the growth of psittacine chicks, Renton (2002) studied *Amazona finschi*'s chicks during two breeding seasons. Tropical forests in Central America may experience environmental inter-annual fluctuations which influences the production of seeds and fruits thus food availability. *A. finschi* chicks grew more quickly as a result of the increase in food availability during periods of higher rainfall. Limitations for brood size in this habitat were suggested because hatching sequence had great influence on the body weight increment, with third hatched chicks being smaller than first or second hatched chicks (Renton, 2002).

Cyanoliseus patagonus is another example of a psittacine species which its growth rate was studied in the wild. Masello (2001) observed large variability in growth parameters between chicks, concluding that either food availability or delivery rates may limit chick development. First hatched received more food than middle and last hatched chicks. Growth rates could thus reflect both environment and parental quality and be highly variable in years of abundant food (Masello & Quillfeldt, 2001).

Ara macaw's chick growth was studied in Peru by Vigo (2010). Chicks had a short stationary phase of two days in which body weight gain was minimal, then entered a logarithmic growth phase of thirty days, peak body weight at the age of sixty three days and slowly lost body weight until fledgling. There were recorded only slight differences among growth parameters for first, second and lone chicks. Growth rate for chicks in one chick brood were greater compared to both first and second chicks in two chicks brood. This suggests that lone chicks receive more food at a younger age then chicks in two chick broods (Vigo *et al*., 2010).

Stoleson (1996) studied the impact of hatching asynchrony, brood reduction and food limitation in the growth of *Forpus passerinus*. Asynchrony appeared to affect the distribution of food within broods in favor of large chicks. Some mortality of smaller chicks was not due to starvation but rather due to the size disparities among siblings. Older chicks did not appear to benefit from the death of their younger siblings. Parents, however, may potentially beneficiate with brood reduction, needing to spend less energy in food delivery (Stoleson & Beissinger, 1996).

Forpus passerinus was also the subject of study used by Pacheco (2010) to evaluate the possible advantages of growth regulation in less favorable conditions. It was shown that when food quality was lessened, the limiting nutrients were deposited at slow rates. Decreasing the growth rate would lessen the demands for nutrients by the young chicks, allowing parents to successfully feed large numbers of offspring on abundant but nutritionally poor food (Pacheco *et al*., 2010).

A comparative study between chicks of the *Amazona aestiva* raised in the wild and in captivity was made by Seixas (2003). *A. aestiva* wild chicks lost, on average, 4% of their body weight before flying. However, chicks of both sexes raised in captivity kept gaining weight and were, on average, 3.5% heavier than wild chicks before leaving the nest. This is possibly because in captivity there is no food limitation at the final stage of growth and cage conditions like shade and ventilation resulted in lower energetic consumptions for thermoregulation. Nonetheless, chicks raised in captivity showed slower growth than free living ones. Slower growth in captive birds may be associated to the frequency of food provision and food quality. The long-term effects of this delayed growth are not yet clear. There is little information on *A. aestiva* natural feeding habits and young chicks' nutritional requirements are largely unknown. There were no difference in wild birds growth, but slight differences were observed for captive animals. This can be explained by small changes in the diet composition served in captivity, or the temperature variations in insulated cages as observed in other studies (Seixas & Mourão, 2003).

SIGNS OF DISEASE

Though it was not part of this study's main goal, a quick evaluation of the sick variable was made. Two figures, 68 and 69, were elaborated in order to analyze what were the most common signs of disease (SOD) and how they affected each species.

In psittacines the identification of SOD can be challenging. Existent directives are not one hundred percent objective to classify a chick as unhealthy (Flammer & Clubb, 1997; Romagnano, 2012). Processing data obtained proved to be complex for this reason, since many *healthy* chicks died during the weighing period and had to be reclassified as *sick*.

In Figure 68 it was observed that the most common SOD is lethargy, followed by omphalitis and crop stasis. Regurgitation, edema, beak trauma and YSR have the lower representation.

According to Figure 69, lethargy was observed in fourteen of the fifteen species. This data is in accordance to the literature, since lethargy is the most common sign of disease in birds, being sometimes the only sign present (Flammer & Clubb, 1997; Harcourt-Brown, 2009; Duff, Gavier-Widen & Meredith, 2012)

Omphalitis was observed in six out of 15 species. According to Flammer & Clubb (1997) this may be due to incorrect incubation temperature and/or humidity, parenteral malnutrition and inadequate ventilation. In recently hatched chicks, omphalitis is a common sign of infection acquired through the environment (Flammer & Clubb, 1997).

Crop stasis was also highly prevalent (six out of 15 species) being management the main reason for this problem. Some examples are food fed at the wrong temperature or consistency, little time between feedings, incorrect incubation temperature and humidity (Gelis, 2006).

Diarrhea, like lethargy, is by itself a vague sign of disease. Bacteria, virus, fungi, parasites, chlamydophila, nutritional deficiencies (i.e. lack of vitamin B2), toxins (i.e. some detergents) and lack of hygiene are behind the most common causes of diarrhea in nurseries (Flammer & Clubb, 1997).

Regurgitation can be related with management but it can also be behavioral (over stretching the crop, aerophagia, fear and excitement). Crop stasis, crop burns, overheated or under-heated formula, foreign body ingestion and a various number of infectious agents are listed as causes of regurgitation in baby chicks (Flammer & Clubb, 1997).

Beak trauma can be done by the keepers while feeding or by chicks housed together (Flammer & Clubb, 1997; Gelis, 2006). Gelis (2006) refers that hypovitaminosis A is associated with significant beak deformities in handfed *Psittacus erithacus* chicks.

Yolk Sack Retention is considered normal until the chick is two weeks of age. Causes for its retention are unknown and therefore very difficult to predict and control (Langenberg *et al*., 1983). High humidity or low temperature have been associated to bacterial sacculitis and therefore pointed out as a probable cause (Langenberg *et al*., 1983; Flammer & Clubb, 1997).

Most SODs are associated to management issues. Even though many procedure lists have been made to minimize human error, Table 3, intends to provide further guidelines on correct nursery practices. Decreasing human error will improve nursery's growth and success rate.

Table 3. Guidelines for Nursery Management - adapted from Flammer & Clubb (1997).

Guidelines for Nursery Management	
1	Every nursery should have a separate room where sick birds can be isolated. This room should not share air flow with the primary nursery. Chicks showing signs of disease should be immediately moved and isolated.
2	If a chick leaves the nursery and is exposed to other birds, it should not be returned to the primary nursery.
3	Chicks should never be added from another facility.
4	The same people should not care for both the adults and the neonates. If that is not possible, individuals must be handled from youngest to oldest.
5	Visitors should be restricted from entering the nursery.
6	Thorough cleaning of nursery facilities and equipment is better than partial cleaning followed by the use of disinfectants. Disinfectants are toxic, and exposure should be minimized (both direct contact and fumes).
7	Feeding practices: a. Use a proven diet and constantly evaluate growth by assessing development and comparing weight gains with a growth chart. b. Store dry diet in a cool, dry, rodent-free area. Opened food containers should be stored in the freezer. c. Feeding formula should be carefully measured, mixed and the temperature checked before feeding. d. Mix food fresh for each feeding. Do not store mixed food in the refrigerator and feed it at a later time. e. Use an individual syringe for each chick. f. Never feed a bird and place the syringe back in the feeding formula.
8	Substrate should not be slippery and should be harmless if swallowed.

CONCLUSION

What is the standard value of weight gain/day in selected species of psittacines?

With this study it was possible to obtain a number of growth curves from 15 species of psittacines. Although a greater number of species was considered in the beginning, the insufficient number of individuals per species was, ultimately, the cause to exclude many species from the study.

The purpose of this study was achieved for the species *Ara glaucogularis*, *Aratinga solstitialis*, *Cacatua galerita*, *Poicephalus robustus*, *Psittacus erithacus*, *Pyrrhura perlata* and *Trichoglossus haematodus*, as representative growth curves were obtained. This is the first study on weight gain/day for these species. These results can be extrapolated to related species.

Along with other studies published in this area, it is possible to extrapolate the obtained data not only to the respective subspecies, but to other individuals from the same genus. Being so, is possible, with a minor margin of error, to predict the expected weight gain/day for chicks from the genus *Ara, Aratinga, Cacatua, Poicephalus, Pyrrhura* and *Trichoglossus* disregarding the species or subspecies.

Curves for the species *Amazona vinacea*, *Eclectus* roratus, *Nestor* notabilis, *Pionites* leucogaster and *Primolius couloni*, though not satisfying the premise N≥8, presented results with a high confidence level and followed the pattern of other avian growth curves. Therefore these results can be considered valid. Nonetheless, it would be interesting to increase the number of animals studied and confirm the obtained results.

The evaluation of signs of disease as a complementary part of this study was of particular relevance. The goal was not only to identify the most common diseases and its causes, but highlight the importance of prevention and early symptom identification.

It would have been interesting to access if weight gain/ day oscillated before and after disease. A comparative study of the obtained curves in sick and healthy animals would provide further knowledge in this field and the relevance of weight oscillations on predicting disease.

In the future, it would be interesting to do this research with a larger number of animals, as well as a broader number of species. Also, some improvements to the present study could be applied:

- A larger period of time, including more than one breeding season would enlarge the sample and raise the confidence interval, especially for the species that didn’t met the N≥8.

- Because variable control in the nest is more difficult than in the incubator, a division between *nest* and *incubator* individuals would decrease weight variations hence increasing the confidence interval.

- Subspecies division would also increase the confidence interval, especially when adult size between two individuals from same species but different subspecies is very discrepant.

- Weight curve fluctuation will always be present due to the genetic variability between individuals of the same species and subspecies. Classification by gender can help on this issue, especially when a marked sexual dimorphism is present.

- Other consideration has to do with the disease effect; it must always be taken into account.

Overall, the proposed objective of this study was reached.

This is the first study on weight gain/day for a variety of species, which can be extrapolated to related species. Its importance reaches biologists, breeders, veterinary clinicians, conservation centers and anyone interested in psittacine development. Weight gain is an important tool on the evaluation of young chick development because, usually, the first sign of disease in a young chick is the lack of (expected) weight gain. More importantly, weight measurement is an objective parameter, better than other subjective ones like the signs of disease described above.

The present study provided data on the development of chicks of species such as *Ara glaucogularis*, that are in CITES list of critically endangered species, whose survival depends on the success of breathing centers such as Loro Parque.

In the future, it is expected that similar studies will be performed in different species, using weight measurements and/or different biometric parameters to access psittacine development. Such studies would allow a greater comprehension about this stage of development and help on the successful breeding of many psittacine neonates.

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APPENDIX I

Table 4. *Amazona vinacea*'s mean weight/day in grams:

Day	Mean	Lower	Upper
1	13,80	12,76	14,84
2	14,60	13,18	16,02
3	17,20	15,58	18,82
4	19,80	17,41	22,19
5	22,40	20,32	24,48
6	25,40	22,28	28,52
7	28,80	25,97	31,63
8	31,80	28,59	35,01
9	36,00	31,79	40,21
10	39,80	34,65	44,95
11	43,40	38,46	48,34
12	46,60	40,87	52,33
13	49,60	42,02	57,18
14	52,20	43,95	60,45
15	66,00	49,09	82,91
16	62,20	50,57	73,83
17	69,20	55,45	82,95
18	75,20	61,50	88,90
19	84,40	63,72	105,08
20	91,20	71,35	111,05
21	96,20	75,10	117,30
22	106,40	82,15	130,65
23	117,20	93,55	140,85
24	129,00	100,86	157,14
25	141,20	109,21	173,19
26	155,80	120,36	191,24
27	166,60	132,93	200,27
28	178,80	147,41	210,19
29	187,40	158,10	216,70
30	200,80	173,04	228,56
31	212,60	179,59	245,61
32	226,20	196,71	255,69
33	236,00	202,35	269,65
34	250,00	218,70	281,30
35	254,80	222,36	287,24
36	261,60	230,18	293,02
37	274,40	246,27	302,53
38	289,20	260,81	317,59
39	297,60	270,16	325,04
40	306,60	274,74	338,46
41	314,60	278,70	350,50

Table 5. *Ara glaucogularis*'s mean weight/day in grams:

Day	Mean	Lower	Upper
1	18,63	17,37	19,88
2	19,63	18,53	20,72
3	21,31	19,95	22,67
4	24,06	22,76	25,36
5	27,25	25,92	28,58
6	30,75	29,29	32,21
7	35,06	33,59	36,54
8	39,44	37,96	40,92
9	44,31	42,76	45,87
10	49,63	47,61	51,64
11	55,44	52,07	58,81
12	61,25	56,81	65,69
13	67,00	61,94	72,06
14	73,38	66,76	79,99
15	80,88	72,91	88,84
16	88,75	79,17	98,33
17	97,56	86,01	109,11
18	108,25	95,31	121,19
19	122,50	107,39	137,61
20	134,19	118,65	149,72
21	148,88	131,04	166,71
22	164,63	144,43	184,82
23	181,06	159,93	202,20
24	200,50	176,56	224,44
25	222,56	195,80	249,33
26	234,06	207,74	260,39
27	256,00	220,43	291,57
28	286,13	252,73	319,52
29	308,56	273,01	344,11
30	329,00	292,75	365,25
31	351,94	313,30	390,58
32	378,75	337,74	419,76
33	408,19	363,47	452,91
34	433,75	388,88	478,62
35	460,56	413,81	507,32
36	489,38	439,54	539,21
37	519,94	472,19	567,69
38	547,44	498,51	596,36
39	570,63	520,79	620,46
40	596,50	551,00	642,00
41	624,63	579,31	669,94
42	645,25	601,02	689,48
43	667,94	624,48	711,39
44	686,00	641,04	730,96
45	711,50	672,46	750,54
46	725,56	682,85	768,27
47	747,81	704,12	791,51
48	760,63	723,20	798,05
49	782,13	748,76	815,49
50	791,81	755,86	827,76
51	799,69	764,94	834,43
52	823,31	790,85	855,77
53	823,93	793,55	854,32
54	836,80	805,82	867,78
55	854,00	825,05	882,95
56	852,92	815,85	890,00
57	862,31	838,11	886,51
58	867,81	846,46	889,17
59	873,00	850,38	895,62
60	879,46	857,08	901,84
61	879,36	859,26	899,46
62	890,21	871,52	908,91
63	873,57	857,00	890,14
64	882,94	865,67	900,20
65	878,67	859,94	897,40
66	880,20	858,37	902,03
67	885,67	862,10	909,23
68	868,92	845,97	891,87
69	864,77	846,76	882,78
70	853,40	825,05	881,75
71	863,93	839,81	888,05
72	853,79	827,57	880,00
73	851,64	823,31	879,98
74	859,64	829,06	890,21
75	835,92	809,14	862,71
76	839,21	813,42	865,01
77	819,10	789,45	848,75
78	824,33	800,71	847,96
79	816,14	788,85	843,44
80	813,93	785,96	841,90
81	813,27	781,24	845,31
82	795,38	769,02	821,75
83	799,36	769,97	828,74
84	785,90	749,95	821,85
85	785,73	758,66	812,81

Table 6. *Aratinga solstitialis*'s mean weight/day in grams:

Day	Mean	Lower	Upper
1	5,33	3,90	6,77
2	6,00	6,00	6,00
3	7,00	7,00	7,00
4	8,00	8,00	8,00
5	9,50	8,77	12,00
6	11,00	9,41	14,00
7	12,00	12,00	16,00
8	14,50	13,00	17,82
9	15,90	11,00	20,85
10	17,03	13,00	27,71
11	21,00	15,00	29,71
12	38,67	16,00	57,00
13	47,60	16,43	58,71
14	48,43	31,21	65,65
15	50,57	32,73	68,41
16	52,38	35,42	69,33
17	56,89	42,54	71,24
18	59,70	46,41	72,99
19	65,36	53,38	77,35
20	68,91	57,13	80,69
21	73,25	62,74	83,76
22	77,58	67,65	87,52
23	81,83	72,14	91,53
24	81,46	70,84	92,08
25	83,77	72,54	95,00
26	88,54	77,38	99,70
27	92,62	81,55	103,69
28	96,92	86,15	107,70
29	100,92	90,37	111,48
30	102,62	93,00	112,23
31	105,54	96,36	114,72
32	108,33	99,13	117,53
33	110,85	103,02	118,67
34	112,85	106,01	119,69
35	114,50	107,68	121,32
36	115,67	109,27	122,06
37	117,67	111,54	123,79
38	120,18	113,85	126,51
39	120,75	113,66	127,84
40	119,38	112,03	126,72
41	117,57	109,76	125,38

Table 7. *Cacatua galerita*'s mean weight/day in grams:

Day	Mean	Lower	Upper
1	16,85	15,83	17,86
2	18,93	17,79	20,07
3	22,21	20,50	23,93
4	27,14	23,58	30,70
5	30,07	27,43	32,72
6	35,07	31,91	38,23
7	40,07	36,55	43,60
8	45,50	41,07	49,93
9	51,64	45,57	57,71
10	57,00	50,13	63,87
11	65,14	56,50	73,79
12	72,93	63,13	82,73
13	81,86	69,86	93,85
14	91,21	77,71	104,72
15	101,29	87,18	115,39
16	112,43	96,80	128,05
17	123,07	105,96	140,19
18	134,57	115,42	153,72
19	148,00	126,13	169,87
20	160,79	135,60	185,97
21	172,14	144,93	199,35
22	179,00	151,14	206,86
23	202,36	171,61	233,10
24	215,07	181,08	249,06
25	232,36	195,33	269,38
26	251,21	216,91	285,52
27	268,57	230,87	306,27
28	281,64	242,32	320,96
29	266,69	203,17	330,21
30	313,77	265,66	361,88
31	327,46	278,70	376,22
32	340,58	285,69	395,48
33	354,64	307,14	402,14
34	369,21	320,77	417,66
35	382,83	325,44	440,23
36	397,93	348,77	447,09
37	406,17	347,86	464,47
38	433,21	379,48	486,95
39	434,23	380,30	488,16
40	457,62	398,23	517,00
41	471,17	406,42	535,91
42	480,54	421,36	539,72
43	497,56	420,34	574,78

Table 8. *Eclectus roratus*' mean weight/day in grams:

Day	Mean	Lower	Upper
1	15,00	12,09	17,91
2	17,60	15,03	20,17
3	19,60	16,48	22,72
4	20,80	18,41	23,19
5	23,00	20,52	25,48
6	26,60	22,43	30,77
7	30,20	23,61	36,79
8	34,20	24,45	43,95
9	37,60	25,67	49,53
10	42,60	26,95	58,25
11	48,00	28,62	67,38
12	52,20	28,85	75,55
13	50,50	26,67	74,33
14	54,17	28,57	79,76
15	56,67	30,57	82,76
16	60,83	33,59	88,08
17	66,67	35,42	97,92
18	71,67	39,21	104,13
19	79,33	42,96	115,71
20	85,17	46,47	123,86
21	92,17	50,61	133,72
22	100,00	56,19	143,81
23	108,83	61,42	156,25
24	127,60	68,26	186,94
25	119,40	61,86	211,94
26	149,60	89,04	210,16
27	156,00	89,63	222,37
28	146,00	76,17	215,83
29	178,20	98,70	257,70
30	189,40	108,57	270,23
31	204,20	116,70	291,70
32	209,20	123,51	294,89
33	212,83	131,62	294,04
34	228,50	150,07	306,93
35	227,50	158,64	296,36
36	234,17	166,95	301,38
37	247,33	161,00	316,67
38	249,33	172,21	326,46
39	254,17	178,95	329,38
40	259,83	188,67	331,00
41	248,50	146,42	350,58
42	259,75	162,05	357,45
43	272,00	169,31	374,69
44	280,00	177,07	382,93
45	282,00	212,29	351,71
46	251,50	154,55	348,45
47	252,50	155,55	349,45
48	255,50	160,20	350,80
49	271,50	209,73	323,27

Table 9. *Nestor notabilis*' mean weight/day in grams:

Day	Mean	Lower	Upper
1	15,25	12,86	17,64
2	16,00	14,16	17,84
3	17,50	15,91	19,09
4	21,00	19,16	22,84
5	24,50	22,45	26,55
6	28,75	24,57	32,93
7	35,80	27,31	44,29
8	37,20	32,78	41,62
9	42,40	37,39	47,41
10	50,20	43,43	56,97
11	57,60	51,42	63,78
12	65,80	60,02	71,58
13	77,00	67,58	86,42
14	89,00	79,63	98,37
15	100,80	85,18	116,42
16	121,60	105,93	137,27
17	137,40	117,02	157,78
18	148,20	130,92	165,48
19	164,20	145,86	182,54
20	191,20	162,76	219,64
21	213,40	177,00	249,80
22	230,40	193,32	267,48
23	257,00	215,72	298,28
24	323,00	234,92	411,08
25	322,33	235,95	408,72

Table 10. *Pionites leucogaster*'s mean weight/day in grams:

Day	Mean	Lower	Upper
7	27,00	14,99	38,41
8	32,00	19,57	58,32
9	45,00	24,15	62,23
10	49,00	28,73	66,14
11	52,50	33,31	70,05
12	58,00	37,89	73,96
13	63,33	42,47	77,87
14	65,50	43,97	87,03
15	69,00	56,52	81,48
16	71,00	54,63	87,37
17	77,33	61,42	93,24
18	80,67	64,80	96,54
19	85,83	69,42	102,25
20	90,67	74,73	106,61
21	95,83	78,18	113,49
22	106,75	82,29	131,21
23	108,20	88,00	128,40
24	111,17	95,84	126,50
25	117,80	97,95	137,65
26	121,20	101,48	140,92
27	124,17	109,57	138,76
28	127,33	114,33	140,33
29	131,00	117,03	144,97
30	134,00	121,62	146,38
31	137,67	126,63	148,71
32	140,67	129,39	151,94
33	143,67	134,06	153,28
34	146,50	136,51	156,49
35	151,50	143,08	159,92
36	154,33	148,08	160,58
37	156,60	148,57	164,63
38	159,20	150,19	168,21
39	160,60	153,82	167,38
40	162,00	152,11	171,89
41	165,00	156,49	173,51
42	169,75	164,18	175,32
43	173,33	167,08	179,58

Table 11. *Poicephalus robustus*' mean weight/day in grams:

Day	Mean	Lower	Upper
13	64,50	45,06	82,21
14	63,00	48,65	85,65
15	65,25	50,06	84,44
16	77,83	55,85	99,82
17	83,00	61,46	104,54
18	93,14	75,51	110,78
19	101,43	86,04	116,82
20	112,00	97,67	126,33
21	118,29	99,82	136,75
22	130,25	116,21	144,29
23	140,63	126,23	155,02
24	148,25	132,57	163,93
25	163,57	143,41	183,73
26	166,75	144,16	189,34
27	172,50	151,09	193,91
28	179,13	158,98	199,27
29	185,50	159,96	211,04
30	194,13	171,82	216,43
31	209,88	183,46	236,29
32	218,75	189,45	248,05
33	225,00	195,16	254,84
34	239,50	219,57	259,43
35	241,78	215,96	267,60
36	235,11	205,14	265,09
37	230,38	194,81	265,94
38	240,29	198,06	282,51
39	238,44	205,65	271,24
40	239,56	208,32	270,79
41	257,00	220,14	293,86
42	274,00	247,12	300,88
43	278,33	243,69	312,97
44	263,67	239,30	288,03
45	266,40	232,88	299,92
46	261,00	209,31	312,69
47	289,75	199,58	379,92
48	275,00	243,06	306,94
49	282,25	243,70	320,80
50	290,33	233,83	346,83
51	287,50	227,02	337,98
53	268,50	227,16	324,16
54	294,00	253,66	351,66

Table 12. *Primolius couloni*'s mean weight/day in grams:

Day	Mean	Lower	Upper
1	10,33	8,90	11,77
2	11,00	11,00	11,00
3	13,33	11,90	14,77
4	16,33	14,90	17,77
5	19,33	17,90	20,77
6	22,33	18,54	26,13
7	25,67	22,80	28,54
8	29,67	25,87	33,46
9	30,00	17,20	42,80
10	34,25	18,97	49,53
11	39,50	22,79	56,21
12	46,50	30,67	62,33
13	54,25	33,13	75,37
14	62,25	38,89	85,61
15	71,25	46,79	95,71
16	83,25	53,08	113,42
17	92,25	56,45	128,05
18	106,25	62,03	150,47
19	115,50	75,70	155,30
20	125,00	85,79	164,21
21	137,75	94,18	181,32
22	147,75	105,42	190,08
23	158,50	112,65	204,35
24	167,00	122,31	211,69
25	173,00	127,16	218,84
26	186,25	133,29	239,21
27	203,50	148,77	258,23
28	205,75	150,93	260,57
29	200,50	164,62	236,38
30	210,00	172,19	247,81
31	225,00	192,73	257,27
32	233,75	211,73	255,77
33	243,75	211,29	276,21
34	244,00	207,88	280,12
35	257,00	229,26	284,74
36	260,75	231,57	289,93
37	267,50	243,60	291,40
38	276,50	257,16	295,84
39	284,00	262,34	305,66
40	293,50	223,62	363,38
41	302,33	272,91	331,76

Table 13. *Psittacus erithacus*' mean weight/day in grams:

Day	Mean	Lower	Upper
1	11,87	10,46	13,27
2	13,13	12,13	14,13
3	13,80	11,61	15,99
4	17,20	15,70	18,70
5	19,53	17,55	21,52
6	22,60	19,97	25,23
7	25,93	22,63	29,23
8	29,67	25,44	33,90
9	34,79	29,05	40,52
10	40,92	33,75	48,10
11	46,15	37,74	54,57
12	49,69	40,33	59,06
13	54,46	43,74	65,18
14	59,69	47,32	72,06
15	65,15	51,14	79,17
16	67,29	52,34	82,23
17	70,07	53,93	86,20
18	77,07	59,27	94,86
19	84,53	64,79	104,28
20	93,20	72,54	113,86
21	102,73	80,29	125,18
22	111,00	86,72	135,28
23	120,87	94,42	147,31
24	131,40	102,09	160,71
25	141,93	110,71	173,16
26	152,47	120,09	184,85
27	158,57	122,26	194,89
28	174,20	137,31	211,09
29	185,20	146,08	224,32
30	195,27	155,05	235,48
31	206,60	164,92	248,28
32	218,00	174,18	261,82
33	229,71	180,93	278,50
34	241,85	189,62	294,07
35	239,54	188,79	290,28
36	243,91	188,27	299,55
37	262,00	205,89	318,11
38	258,67	205,96	311,37
39	276,38	224,55	328,22
40	284,46	231,14	337,78
41	290,08	237,37	342,79
42	290,75	234,86	346,64
43	297,58	240,94	354,23
44	291,18	237,65	344,71
45	291,70	231,93	351,47
46	296,20	236,59	355,81
47	306,11	237,21	375,02
48	299,25	226,65	371,85
49	284,00	236,04	331,96

Table 14. *Pyrrhura perlata*'s mean weight/day in grams:

Day	Mean	Lower	Upper
9	23,33	9,05	35,57
10	28,67	11,67	43,12
11	29,75	12,35	47,15
12	33,00	13,60	52,40
13	35,14	24,74	45,54
14	40,09	31,69	48,49
15	43,80	36,90	50,70
16	49,35	41,43	57,27
17	52,79	46,00	59,58
18	54,29	48,66	59,92
19	59,91	54,66	65,16
20	63,15	58,02	68,28
21	65,68	60,87	70,49
22	68,74	64,13	73,34
23	70,05	65,21	74,89
24	74,42	70,23	78,61
25	76,00	71,88	80,12
26	79,06	75,05	83,06
27	80,12	75,94	84,29
28	80,94	77,02	84,86
29	83,06	79,12	87,00
30	83,83	78,89	88,78
31	84,56	79,44	89,67
32	83,88	78,88	88,87
33	85,31	80,07	90,55
34	85,00	80,05	89,95
35	87,64	81,44	93,83
36	89,70	84,49	94,91
37	89,00	81,02	96,98
38	87,75	78,76	96,74
39	86,33	76,02	96,65

Table 15. *Trichoglossus haematodus*' mean weight/day in grams:

Day	Mean	Lower	Upper
1	4,57	4,38	4,77
2	5,00	4,75	5,25
3	5,86	5,53	6,19
4	6,95	6,55	7,36
5	8,11	7,62	8,61
6	9,53	8,87	10,20
7	13,55	7,99	19,11
8	12,38	11,54	13,21
9	13,95	13,06	14,85
10	15,61	14,46	16,76
11	17,42	16,13	18,72
12	19,52	17,97	21,07
13	21,98	20,16	23,80
14	25,39	22,98	27,79
15	27,93	25,17	30,70
16	32,21	29,12	35,30
17	35,78	32,42	39,14
18	39,08	35,54	42,63
19	41,90	38,07	45,73
20	45,90	41,48	50,32
21	49,63	45,29	53,96
22	53,33	48,76	57,91
23	57,72	52,88	62,55
24	61,92	57,01	66,83
25	65,92	60,81	71,02
26	69,75	64,39	75,11
27	75,04	69,58	80,51
28	78,21	72,53	83,89
29	82,44	76,62	88,25
30	85,87	79,94	91,80
31	90,88	84,87	96,90
32	94,44	88,48	100,40
33	98,48	92,42	104,53
34	102,60	96,95	108,26
35	103,46	97,60	109,32
36	106,54	100,83	112,25
37	104,45	98,61	110,29
38	104,28	98,28	110,28
39	107,75	101,20	114,30
40	108,52	100,06	116,98
41	106,65	96,21	117,08
42	109,67	101,10	118,23
43	112,69	101,89	123,48
44	115,50	104,48	126,52
45	116,60	98,46	134,74
46	115,63	95,45	135,80